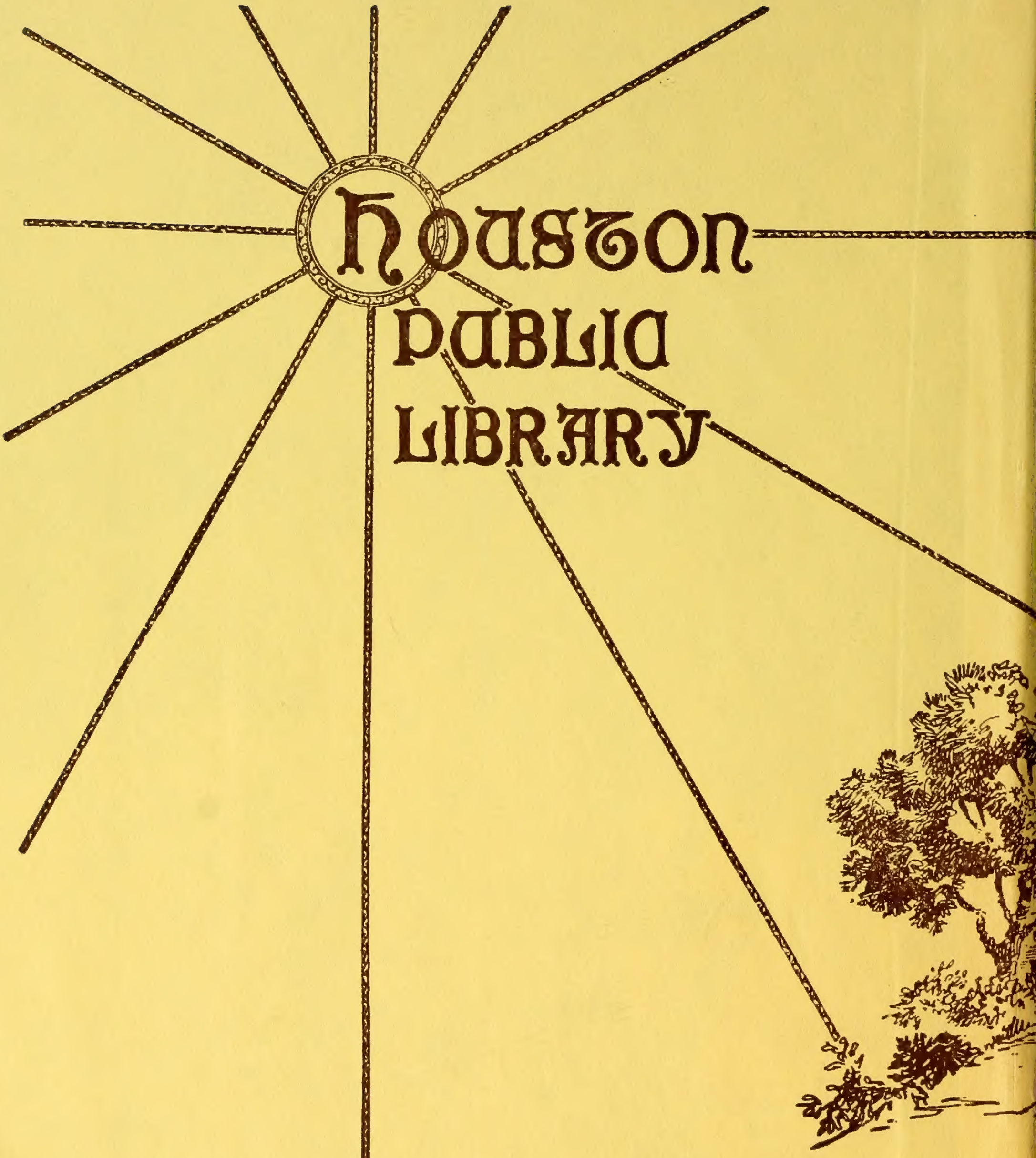

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JANUARY 6, 1964

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THE WEEKLY OF SPACE SYSTEMS ENGINEERING

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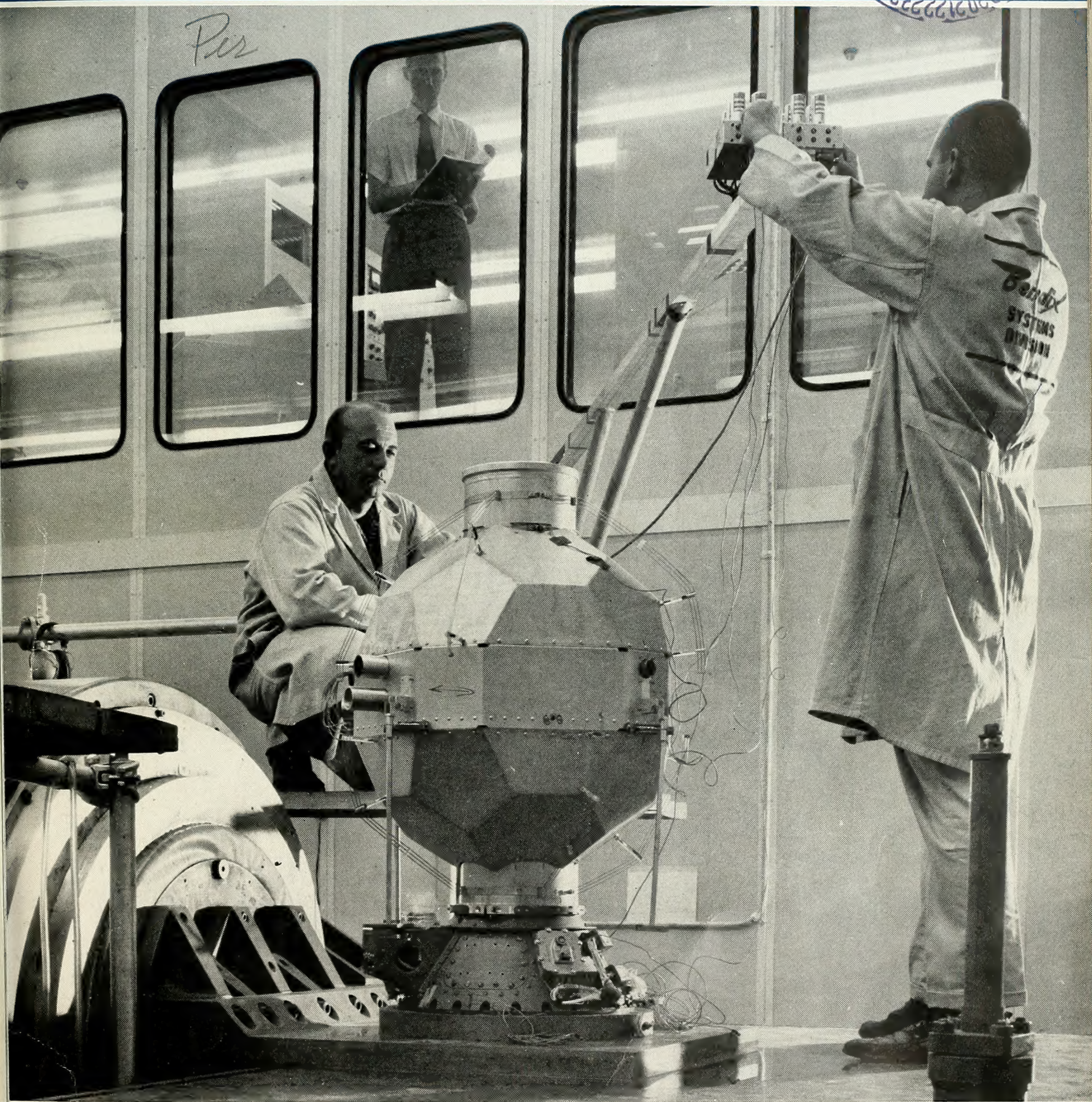

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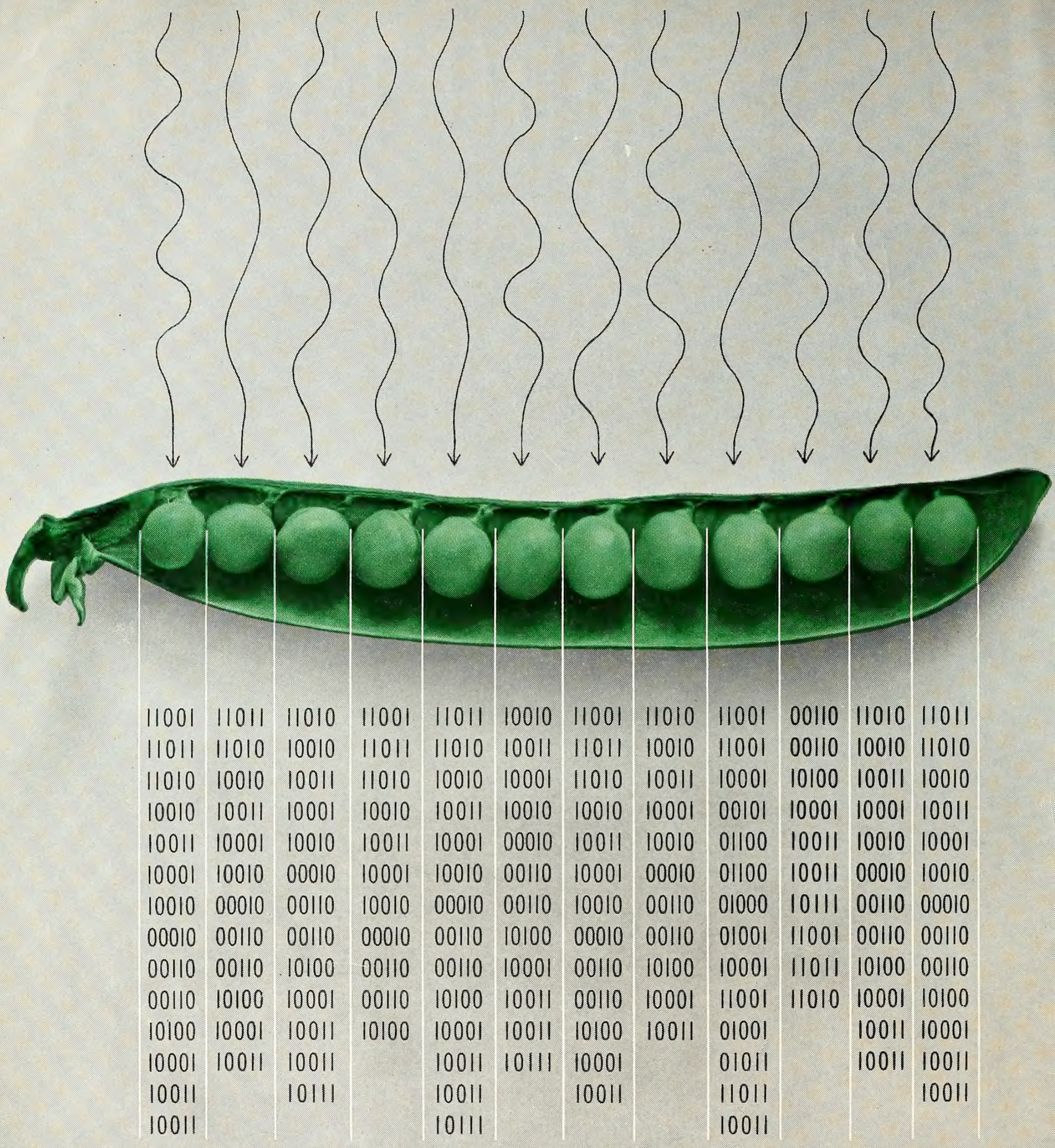
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Memo from the Publisher

THE END OF ONE YEAR and the beginning of another means annual report time for most of the nation's business organizations. It occurred to me that you, our readers, might like to take a look at our past year's progress and be advised of some of our plans for the new year. So here is our annual report to you.

MISSILES AND ROCKETS has just finished its most exciting and rewarding year since its inception in 1956. It has been exciting because we have witnessed further advances in the Space Age and have had the rewarding experience of being a part of it. Our editors traveled thousands of miles in 1963 to attend conferences and visit industry and government plants and installations in order to give you an informed weekly report on the news and technical developments which have helped foster the progress of our industry and the strength of the free world.

It has been our pleasure and privilege to take an active part in selling the need for space exploration to the Congress and the American people. Our editorial pages have been vocal in dealing with the problems that hinder and delay the progress of our age. Not only have we spoken out through the magazine, but our editors have made speeches throughout the states before civic groups and industry leaders to further help them understand what is at stake in the space race. Though MISSILES AND ROCKETS is a small-circulation magazine, compared to national news media, our impact on the nation is great. Every major news commentator, editor and member of Congress concerned with missile/space matters depends on our editorial pages for intelligent guidance in his interpretation of some of the events which control the destiny of our nation and our lives. We feel that we owe to the industry, which invested well over one million dollars in our advertising pages in 1963, the most informed coverage of any trade magazine published today.

Speaking of readers, we are pleased to serve more and more of you as the days go by. Our circulation in 1963 grew by over 3,700 new subscribers, which brings us to a total of over more than 45,000. The subscriber renewal rate is 67.6%, which is high for a trade publication. Most of our increased circulation comes to us through the subscriber card in the magazine, which means many of you share your copy with an associate. We are happy to know that you pass MISSILES AND ROCKETS along to others and we thank you for it.

MISSILES AND ROCKETS' advertising growth continued to set the pace for the industry. Advertising pages for the magazine in 1963 totalled 1,450, which is 275 above 1962. This is the third consecutive year that M/R has shown growth in advertising linage for a total gain of 390 since 1960. The two other major magazines in the field have shown losses. *Aviation Week* has lost 468 pages since 1960 and *Space Aeronautics* is down 1,112 pages for the same period.

SPECIAL REPORTS

We will continue our efforts in the special report area in 1964, the first of which will come Feb. 3, with a complete report on microelectronics. Our three electronics editors, Charles LaFond, Mike Getler and Rex Pay—are presently burning the midnight oil to make it as timely as possible. Other special reports will be announced later in the year as areas of interest for editorial examination develop.

SPECIAL ISSUES

In the special issue department, we will provide you with our annual Department of Defense/Military Systems Issue in March, the popular World Missile/Space Encyclopedia issue in July and the Annual NASA issue in November.

SPECIAL EDITORIAL SERVICES

Inasmuch as space electronics is a big part of space systems engineering, we will be providing you with a more concentrated space electronics section the first issue of each month. Also, the Astrolog will be published five times during 1964 with the first edition coming next week.

All this adds up to say that it has been a sincere pleasure to serve you during 1963 and we look forward to the challenge of the events of 1964 with the confidence that our 17 full-time editors can continue to keep you the most informed people in the Missile/Space Industry. It is to that end that we dedicate our efforts for the coming year.

James W. Claar
Publisher

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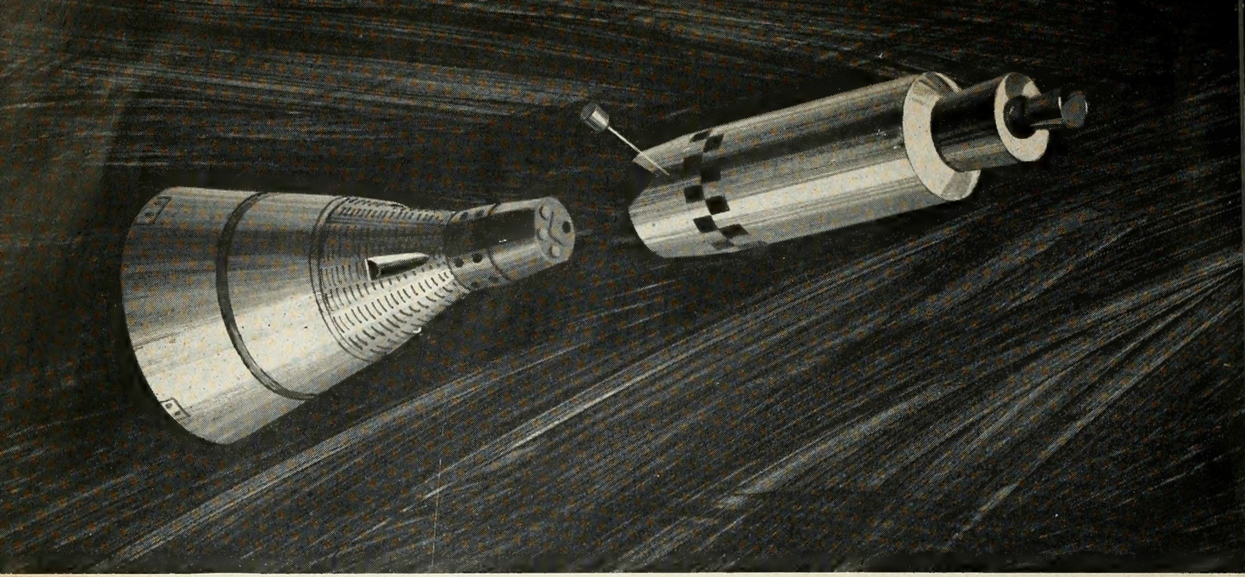
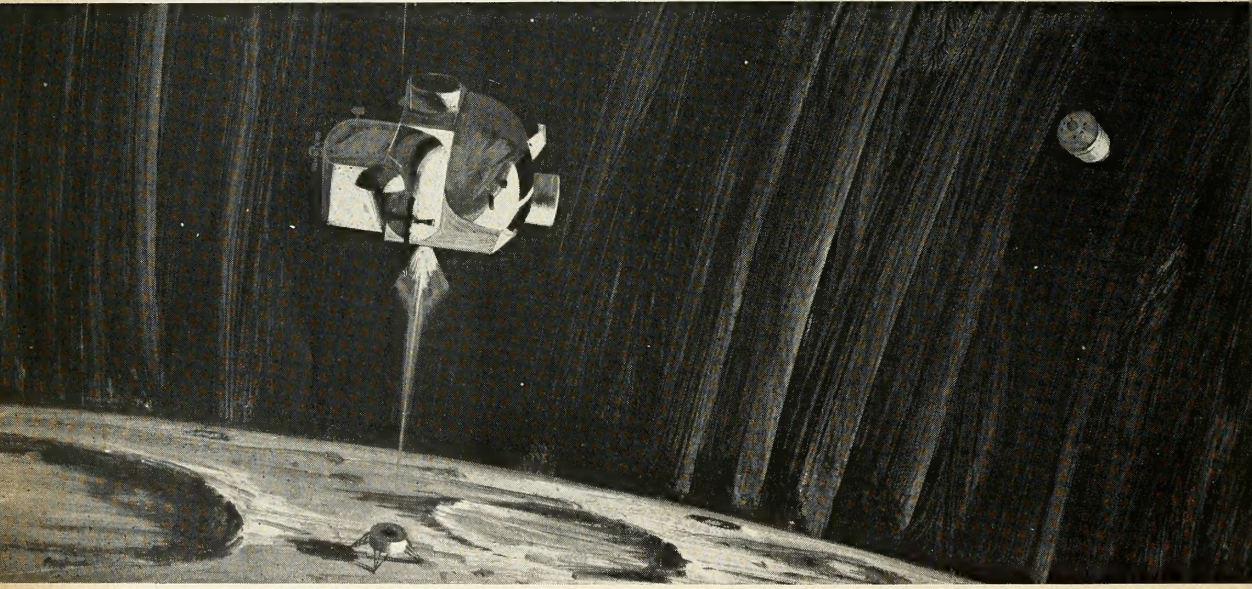


Westinghouse radar will guide the first orbital rendezvous



Westinghouse is working on advanced radar systems for other space missions

When the Gemini two-man spacecraft first performs rendezvous and docking maneuvers in earth orbit, a new Westinghouse radar system will help assure the success of the mission.

The Gemini spacecraft itself, one important mission of which is the perfection of rendezvous techniques, is being built by McDonnell, prime contractor for the Gemini project, under the technical direction of NASA's Manned Spacecraft Center.

Using a unique interferometer system developed by Westinghouse's Aerospace Division, the spacecraft interrogator will transmit a series of pulses to the target transponder. Reply pulses received by the spacecraft will be used to measure range and azimuth and elevation angles.

The first of its kind in space the Westinghouse radar system for Gemini is the beginning of a new generation of advanced radars now being evaluated at Westinghouse for lunar landings, planet exploration, space station logistic support and other space missions. For more information on Westinghouse Aerospace Division space programs, write for brochure No. AD-R-3M1163, to Westinghouse Electric Corporation, P.O. Box 868, Three Gateway Center, Pittsburgh, Pennsylvania 15230.

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missiles and rockets

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Rex Pay	Electronics
Hal Taylor	NASA

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Dr. J. M. Levitt, Dr. Hubertus Strughold

Friedrich Schonbach	Art Director
Donald Strickland	Assistant Art Director
Eleanor Cobey	Editorial Assistant
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THE COVER

Bendix Aerospace Lab technicians prepare NASA's Injun Explorer satellite for environmental tests. Canister at top holds a 12-ft.-dia. inflatable sphere that will be used as an air density explorer after it is ejected, inflated and separated from the satellite. See p. 22.

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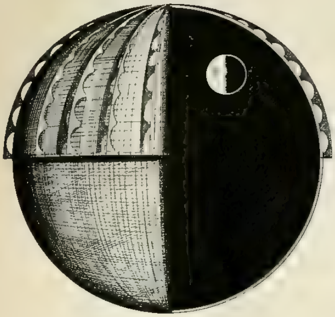

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JPL Advanced Research

To the Editor:

I have enjoyed reading M/R's Third Annual NASA issue (Nov. 25) and appreciate the kind attention given to the Jet Propulsion Laboratory program.

I was particularly impressed with the discussion of the importance of a laboratory such as this one in working in the advanced development areas necessary for successful spacecraft and ground-based tracking installations of the future. My 25 years' experience in research for the government has convinced me that the highly advanced applied research and advanced developments, with its attendant high risks, should be a function of a laboratory within the government or a university laboratory. The proper role of private industry, I believe, is the manufacture of operational hardware under the broad technical direction of a laboratory working in the advanced areas.

I also wish to thank you for featuring the Goldstone Space Communications Station on the cover of this issue, since I am one of the team that is proud to operate this facility.

N. A. Renzetti, Ph. D.
Communication Engineering
and Operations
Jet Propulsion Laboratory
Pasadena, Calif.

In the Running for X-15

To the Editor:

Your article "AF Seeks Renewed *X-15* Interest" (M/R, Dec. 16, p. 39) on the *X-15 A-2* indicates that Emerson Electric Thermo-Lag 500 is "highly favored" by North American Aviation for the ablative coating.

Other materials are being considered.

Thermo-Resist 69 has been successfully flight-flown on the *X-15* at Mach 6 speed, and other tests are planned for the immediate future. Advantages of Thermo-Resist 69 and 69F include: room-temperature curing; non-toxic, non-hygroscopic, flexible materials able to be applied either on the job, pre-molded, or in sheet form; and the high erosion resistance coupled with a low thermal conductivity of 1.8 BTU/ft.^{2}/in./°F allows huge weight savings through use of less material thickness.

Other Thermo-Resist products are also being evaluated by NASA.

Don't count Thermo-Resist, Inc., out of the running, and save your money if you are betting.

Howard C. Litt, Pres.
Thermo-Resist, Inc.
Fullerton, Calif.

Formerly Canaveral

To the Editor:

Considerable controversy has arisen over the recent name change of Cape Canaveral. As a MISSILES AND ROCKETS subscriber and a resident of Rockledge in Brevard County, Florida, I wish to add my comments.

Expressed local opinion throughout newspapers and local city councils has been reported as 10 to 1 against the name change.

Personal opinion as reflected in conversation with colleagues leads me to believe the ratio against the name change is much higher than this.

In your Dec. 9 issue the legality of this change was questioned by State Senator Bernard Parrish. His position has been supported by U.S. Congressman Ed Gurney of Winter Park.

If a publication with the impact of yours would continue to use the name Cape Canaveral, until the legality of the matter has been decided, we would not be faced with the obvious pressure of "the deed is done, let's keep it this way."

F. M. McGranahan
Rockledge, Fla.

Right or wrong, the name change as applied to the Federal reservation is a fact. Unless and until it is ruled illegal, M/R will use the Cape Kennedy dateline.—Ed.

State of EBW Art

To the Editor:

In the article "Reliable Exploding Bridgewire Remains to Be Developed" (M/R, Dec. 16, p. 34), the author summarized EBW as it existed a number of years ago. Since that time, a number of highly reliable and successful systems have been developed and demonstrated. These systems were developed based upon data and research information derived from efforts such as those outlined in the Plenum Press publication "Exploding Wires," Volume II, and other, unpublished, experiments.

The reliability of EBW ordnance systems has been demonstrated on some of our most prominent missiles and rockets. These include the *Polaris A3, Pershing* and the *Saturn*. All three have had extraordinary success with their EBW systems.

Even these operational systems are obsoleted by today's more reliable and advanced EBW systems. The Hi-Shear Corporation is currently manufacturing an advanced EBW system which meets and exceeds the requirements imposed by the author of the EBW article. Hi-Shear EBW devices meet MIL-STD 300 series environments; will not fire when subjected to 500 VDC; will not fire when pulsed from a 500-picofarad capacitor charged to 25,000 volts; will not fire when exposed to RF power as high as 5 watts applied directly to the pins for frequencies of 40 KC through 16 gigacycles.

Weldon Bankston
Exploding Bridgewire Ordnance
Hi-Shear Corporation
Torrance, Calif.

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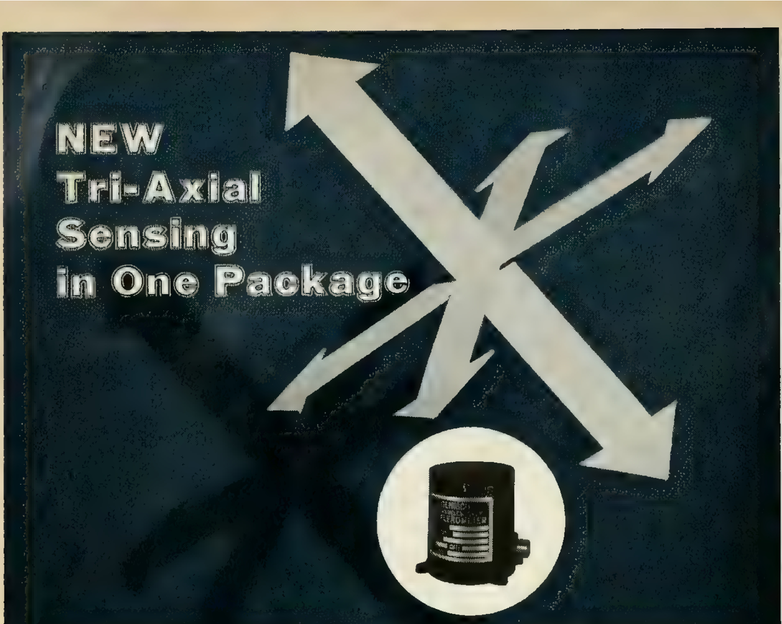

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This new compact tri-axial accelerometer operates over an extremely wide temperature range and doubles the usual accelerometer capability for vibration environment. The integral unit design of the 2404 reduces the normal problem of customer alignment of individual single axis accelerometers since good axis alignment is built-in. Possessing good linearity, hysteresis and threshold characteristics, this accelerometer is lightweight for a tri-axial unit and costs less than three individual single axis accelerometers. Its high reliability is performance proved in missile, rocket and aircraft flight control systems. It is also available as a two axis unit.

For additional information, write for data file MR-2441-1

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Environmental Capability:	
Temperature:	−100° F. to +250° F.
Vibration, Sinusoidal:	20 g's from 20 to 2000 cps.
Random Noise:	0.09 g^2 per cps from 20 to 2000 cps.
Shock:	100 g's for 11 ± 1 msec. in each sensitive axis.
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The Countdown

WASHINGTON

Typhon Program Is Under Review

Navy's *Typhon* program has been undergoing close scrutiny in the budget review, but a Pentagon source says reports of cancellation are "somewhat premature." *Typhon*, scheduled for testing aboard the USS Norton Sound this year, has been encountering development troubles. Primary contractors: Bendix and General Dynamics/Pomona.

Gemini Flight Slips to March

First flight of the *Gemini* spacecraft now has slipped into March. The three-month slippage in the program makes it certain that there will be no U.S. manned space flight in 1964. This will mean even more problems for the space agency's Fiscal 1965 budget as it travels the hard road through an election-year Congress.

Mauler Is Beset With Delays

Army's *Mauler* tank-to-air missile has run afoul of technical problems, primarily involving guidance, which have raised the possibility of cancellation. Army Missile Command has backed off for a thorough review. Prime contractor: General Dynamics/Pomona.

NASA Position on MOL Explained In-House

An internal, official NASA position paper on the Air Force *Manned Orbiting Laboratory* holds that it should not be considered the *National Space Station*. The paper declares that the *MOL* project was implemented solely in response to military requirements. NASA experiments will be conducted in *MOL* only on a non-interference basis. Studies of the *National Space Station* program will continue in both agencies, the paper declares.

Johnson May Attend Cape Dedication

President Johnson is considering a trip to Florida for the dedication of the John F. Kennedy Space Center. Date for the trip tentatively is being set to coincide with the launch of the *SA-5 Saturn* booster—still scheduled for late this month.

Future of M-1 Engine Still in Doubt

NASA still has not made a decision as to whether to continue the M-1 engine as a full-scale development program or to cut it back to a simple component development project. Transfer of the M-1 from the Office of Manned Space Flight to the Office of Advanced Research and Technology probably is a harbinger of darker days ahead for the large liquid hydrogen-powered engine.

MMRBM Expected to Continue in '65

Air Force's *Mobile Medium Range Ballistic Missile* (*MMRBM*) appears to be on solid ground. Contractors now are signing Phase II contracts, which usually would indicate Fiscal 1965 budget commitments.

INDUSTRY

How to Abandon Ship in Space

North American Aviation is investigating crew escape from space vehicles at super-orbital re-entry speeds of 24,000 mph, as well as the possibility of transfer from a damaged space station to another station in a lightweight rescue capsule. NAA's Columbus Division and the Space and Information Systems Division are assigned the NASA studies, totalling $127,000.

Astronauts Sell Out Interest at Cape

The seven *Mercury* astronauts have sold their interest in the Cape Colony Inn motel in Cocoa Beach, Fla. It's understood that they made a small profit on their original investment of $7500 each. Shares were sold to W. H. Rose, major stockholder.

Defective Sleeves Replaced on SA-5

Last of the defective pneumatic sleeves on *Saturn SA-5* was replaced last week at Cape Kennedy. Defects caused more than a month's postponement of the shot. Entire vehicle now is being tested prior to the late January launch.

Propulsion Experts Shifted at NASA

Two of NASA's top propulsion experts, A. O. Tishler and William Cohen, will move from the Office of Manned Space Flight to the chemical propulsion office in OART. Tishler will direct the newly-created office, formerly known as the office of propulsion and space power generation. Cohen will direct the solid motor demonstration program.

AADS-70 Contracts Are Extended

Three contractor teams studying AADS-70, the proposed Army air defense system for the 1970's, have been granted 45-day contract extensions of more than $180,000 each. After completion of the studies in mid-January, the field will be narrowed to two for a run-off in the program definition phase. Competitors and principal associates include Raytheon (with IBM and Northrop), Hughes Aircraft (with FMC and Douglas Aircraft), and RCA (with Beech Aircraft).

First Apollo Fuel Cells Accepted

First three prototype fuel cells for the *Apollo* spacecraft have passed their NASA acceptance tests and have been delivered by Pratt & Whitney to North American Aviation. Criteria required that the cells operate over a 500-to-2,000-watt power output range and produce water that would meet U.S. government purity standards.

INTERNATIONAL

NASA Tracking Station in Spain Studied

A new tracking center may be built in Spain as part of NASA's Deep Space Instrumentation Facility. Talks have been held with Spanish space agency officials on this, but no final decision has been reached.

British Polaris Sub is On Schedule

Britain's first *Polaris* submarine is on schedule, according to an Admiralty spokesman. The sub is to be launched early this year but no date has been announced.

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SPACE AND INFORMATION SYSTEMS DIVISION
NORTH AMERICAN AVIATION

The Missile/Space Week

Gen. Phillips To Aid Mueller

Air Force Brig. Gen. Samuel C. Phillips has been named deputy director of the *Apollo* Program in NASA's Office of Manned Space Flight, effective Jan. 15.

Gen. Phillips, now vice commander of the AF Ballistic Systems Div., will work with Dr. George E. Mueller, Associate Administrator for Manned Space Flight, who is director of the *Apollo* program. Gen. Phillips will carry the major responsibility for the management and administration of the U.S. manned lunar landing program.

Dr. Mueller will continue to have the major responsibility for technical direction of *Apollo*, in addition to his other duties as head of the Office of Manned Space Flight.

Gen. Phillips has held his present position since last Aug. 16. Before that, he was director of the *Minuteman* Systems Program, Headquarters Ballistic Systems Div., Air Force Systems Command, Los Angeles, since August, 1959. He was chief of logistics for the Strategic Air Command's Seventh Air Division based in England from June, 1956, until August, 1959.

NASA Extends GE Contract

NASA has extended the General Electric Co.'s Project *Apollo* support effort that provides plant and test support services at the space agency's Mississippi Test Facility.

The procurement is expected to exceed $25 million.

Under the extension, GE will provide instrumentation and control systems for a dual S-IC (first stage of *Saturn V*) test stand, and S-II (second stage) test stand; additions to the Data-Acquisition Control Center, the Data-Handling Center, and Central Control; technical systems for the Electronic, Instrumentation and Materials Laboratory, the Sonic Measuring facilities and Components Services Facilities.

Comsat Asks for Proposals

The Communications Satellite Corp. has asked industry to outline design proposals for a system of Earth-circling satellites by Feb. 10. Later in the year, there will be a 6-month design effort leading to selection of the first basic system.

Industry will have a choice of designing either a medium- or high-altitude system. The first, similar in concept to *Telstar* and *Relay*, would require 12 to 18 satellites simultaneously orbiting at 6,000 to 12,000 mi. altitude in two paths passing over the poles and covering most of the Earth.

The high-altitude system possibly would involve only three synchronous satellites resembling *Syncom*. From a 20,000-mi.-plus altitude, three such satellites could cover the globe.

Comsat has set 1966 as launch date and 1967 as operation date for the medium-altitude system and 1968 as completion date for the high-altitude system.

Final choice of systems will be made by the permanent board of directors of Comsat—including three to be named by the President—which will be named after an estimated $200-million stock issue in February or March.

Shots of the Week

A highly successful launch by NASA of the Weather Bureau's *Tiros 8* satellite from Cape Kennedy Dec. 21 highlighted a relatively quiet period at U. S. ranges during the holiday season. See p. 16.

As is customary, Missiles and Rockets did not publish an issue the last week in December. "Shots of the Week," therefore, here includes all missile/space launches announced since our last issue went to press.

- A Soviet-launched missile impacted in its designated target area Dec. 24 south of Hawaii and east of Johnston Island in the Pacific Ocean. The shot presumably was one in a test series the Russians have said would extend through Jan. 25.
- The Air Force launched another secret satellite Dec. 21 from Vandenberg Air Force Base, Calif. The Air Force said only that an improved *Thor-Agena* boosted the satellite. This is the booster used in *Discoverer* series launches.
- The 25th *Minuteman* to be fired by the Air Force from Vandenberg made a routine training flight Dec. 20. The Strategic Air Command crew that fired the ICBM was from Malmstrom AFB, Mont.
- *Cosmos 24*, the 16th satellite launched by the Soviet Union in 1963, was orbited Dec. 19. The unmanned

vehicle carrying scientific instruments was said to be functioning normally by Tass, the Soviet news agency. *Cosmos 24* had a period of 90.5 minutes on its first orbit, an apogee of 253 mi. and a perigee of 131 mi.

● *Explorer 19,* launched "flawlessly" by NASA Dec. 19 from Pt. Arguello, Calif., quit transmitting radio signals shortly after launch, but has been optically tracked and is said to be in proper orbit. The 12-ft.-dia. balloon was designed by Langley Research Center to measure air density at altitudes from 375 to 1,875 mi.

Last Titan II's Operational

The U.S. now has 554 ICBM's ready to fire, according to a Defense Department announcement last week that the last of 54 Martin *Titan II's* had been declared operational.

The nation's arsenal now includes 320 *Minuteman* missiles, 126 *Atlases,* and 54 *Titan I's,* in addition to the 54 *Titan II's.* The most recent wing of 18 *Titan II's* to go operational was a wing at Little Rock AFB, Ark. Other *Titan II* squadrons are located at McConnell AFB, Wichita, Kan.; and Davis-Monthan AFB, Tucson, Ariz.

AMF To Build S-II Carriers

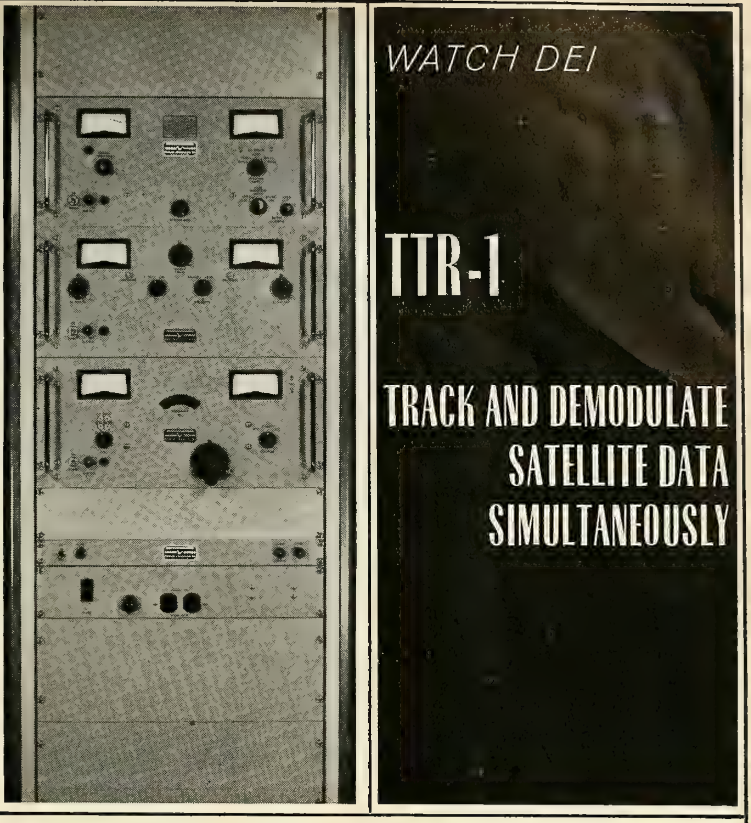
American Machine & Foundry Co. will build five highway transporters for the S-II stage of the *Saturn V* under terms of a $1,181,979 contract awarded by North American Aviation, Inc.'s Space & Information Systems Div. NAA is prime contractor for the *Apollo* program.

Each transporter will be 100-ft. long. One will have six axles and 48 tires. With the 82-ft.-long, 33-ft.-dia. rocket stage aboard, the transporter will weigh about 100 tons.

It will be used to wheel the S-II onto a barge at Seal Beach, Calif., where the stage will be assembled, and will remain with the stage aboard the barge to Port Hueneme, Calif. It will then carry the S-II to Santa Susana, Calif., for static firing and qualification tests.

The other four trailers will each have three axles and 12 tires. They will take the flight-readied S-II stages from Seal Beach onto one of the Military Sea Transportation Service LSD vessels for shipment to NASA's Mississippi Test Facility for further static tests.

Barges will carry the S-II stages on the last leg of the trip to the launch site at Merritt Island, Fla.



Dual Purpose Monopulse 215-260 mc Receiver

- Crystal Controlled or Continuous VFO Tuning
- Complete Telemetry Facilities
- Three Channel Monopulse with DC and AC Error Signals
- Plug-In IF Amplifiers with Switchable Bandwidths
- Optional Phase Lock Demodulators

The ability to track and demodulate IRIG satellite signals *simultaneously* is now possible with the TTR-1 Monopulse Tracking and Telemetry Data Receiver from Defense Electronics, Inc.

Designed for use in advanced aerospace programs, the unit has been refined not only to obtain instant antenna direction for a satellite, but to demodulate and record the signals in conventional telemetry formats.

As a 3-channel tracking receiver in the 215-260 mc band, the TTR-1 has the capability of tracking the RF carrier in a narrow band mode up to the point where good data can be received. Switching to wide band, signals can be demodulated as in other DEI telemetry receivers.

A space saver, the modular TTR-1 employs single-knob tuning with a tuning indicator, choice of two crystals or VFO operations over the complete 215-260 mc band, front-panel switchable IF and video bandwidths. The solid state correlation detectors have excellent noise balance over a bandwidth in excess of 2 mc, allowing use of 1.5 mc IF bandwidths.

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NASA Seeking $5.4 Billion

Also okayed by LBJ is request for Fiscal '64 supplemental funding of $140 million; big engine programs switched to OART

by Hal Taylor

PRESIDENT JOHNSON has approved space agency requests for a supplemental Fiscal 1964 appropriation of about $140 million and a Fiscal '65 budget request of approximately $5.4 billion.

While final details are still being worked out, the funding requests will be included in the President's budget message tentatively scheduled for delivery on Jan. 17.

The big surprise in next year's budget is the transfer of the nation's advanced large solid and liquid propulsion efforts to NASA's Office of Advanced Research and Technology (OART). This includes the switch of the large 260-in. solid motor demonstration program from the Defense Dept., as well as the move of the M-1 engine from the space agency's Office of Manned Space Flight.

The projects will be under the direction of the newly created Office of Chemical Propulsion in OART, which will be headed by A. O. Tishler, former director of liquid propulsion in the Office of Manned Space Flight.

In revealing Presidential approval of the supplemental request, a NASA official said that the funds are needed primarily for its manned space flight activities.

Specifically, the supplemental will be sold to Congress on the basis that the money will be used to lift the job-freeze imposed upon Project *Apollo* contractors on Dec. 12, 1963.

To that end, approximately $110 million will be requested for the *Saturn V* program and $31 million for *Apollo* spacecraft development.

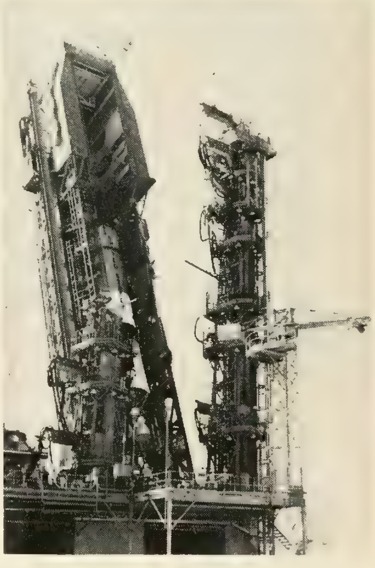
- **Prospects**—Just how the supplemental will fare with election year-minded Congressmen and Senators is a moot point. The strong backing of Johnson, with an otherwise frugal and economy-minded Administration atmosphere, may insure its eventual approval.

With the Fiscal '65 budget request of $5.35 to $5.4 billion, NASA will still be about $200 million below the $5.8 billion it said was needed in the remainder of the current fiscal year and in the next fiscal period if the schedule of landing a man on the Moon is to be maintained.

Sources reported that slightly below $3 billion of the FY '65 budget would be earmarked for its manned space flight activities. This would include about $1.1 billion for the *Apollo* spacecraft and around $900 million for the *Saturn V* and *Saturn IB*.

- **Propulsion plan**—Transfer of the large solid motor demonstration program to NASA will be only a small line item in the space agency's budget, but it does mark a major change in the U.S. space program. NASA was forced to assume funding of the 260-in. program when DOD officials decided to withdraw from the program.

The Pentagon, however, will continue with the 156-in. motor program, which it feels may eventually have a military space application.



FIRST STAGE of Gemini Titan launch vehicle No. 1 goes up at Cape Kennedy.

NASA reportedly will spend about $14 million to complete Phase I of the program, which calls for the firing of one half-size 260-in. solid motor by the prime contractors, Aerojet-General Corp. and Thiokol Chemical Corp.

The space agency will then be faced with a major decision—whether to request funds in FY '66 and '67 for Phase II, which calls for firing of full-size 260-in. motors. A NASA official estimated that it will cost $35 to $40 million to complete the program.

Transfer of M-1 engine from the Office of Manned Space Flight to the Office of Advanced Research and Technology reflects the belief of Dr. George Mueller that the manned space flight officials should not have to work on any vehicles not directly applicable to Project *Apollo*. Thus, the liquid hydrogen M-1, which will be used in a post-*Saturn V* booster, will be moved to the Office of Chemical Propulsion, which also will direct the large solid motor development work.

The four-phase solid motor demonstration program was initiated in April, 1963, by the Defense Dept.

The plan included:

Phase 1: Demonstration static-firing of a 260-in. solid rocket, half-length, of approximately 3 million lbs. of thrust. One such motor is to be fired by Aerojet-General Corp. and another by Thiokol Chemical Corp. This will be funded by NASA.

Phase 2: Demonstration static-firing of a 156-in.-dia., 3-million-lb.-thrust solid with movable nozzle. This motor will be built and fired by Thiokol. This and other 156-in. motor work will be continued under DOD management.

Phase 3: Static firing of a 156-in.-dia., 1-million-lb.-thrust, single-segment solid rocket using movable nozzles for thrust vector control. This will be handled by Thiokol.

Phase 4: Static firings of 156-in.-dia., 1-million-lb.-thrust, single-segment solid rockets using jet tabs for thrust vector control. This assignment goes to Lockheed Propulsion Co. ■

Flight system still planned . . .

RIFT Knocked Out of Rover Program

NASA and the Atomic Energy Commission have announced cancellation of the *RIFT (Reactor In Flight Test)* program and other revisions in the *Rover* nuclear rocket program.

The changes are designed to save some $180 million in Fiscal 1964 and '65.

A breakdown of the figure includes savings of $54 million by the AEC in the next fiscal year, and funding reductions by NASA of $24 million in Fiscal '64, $88 million in Fiscal '65, and $15 million from previous authorized budgets.

Besides killing the *RIFT* project, new plans also call for completion of Kiwi reactor tests in 1964, further work on the Phoebus reactor system and a redirection of the NERVA engine program.

Cancellation of the *RIFT* program came as no surprise. It originally was scheduled for a 1965-66 launch, but the most recent estimate of the earliest date for its first flight was 1970. NASA's present budget problems and the resulting austerity moves, as well as the unlikelihood of any real need for a nuclear rocket until the 1975-85 period, also helped to seal its doom.

The joint announcement declared, however, that the *Rover* projects will be directed toward ultimate use in a flight system as soon as technology from the Kiwi and NERVA projects has been satisfactorily established.

The two agencies also claimed that by reorienting the program, effective use could still be made of the $450 million invested to date in *Rover.*

- **New plan**—The revised program will concentrate on ground reactor and experimental engine research, development and tests with particular emphasis on analyzing and understanding power levels, temperatures, operating life and the problems of frequent and reliable restarts.

Research and engineering development will continue in such areas as advanced reactors to operate at a variety of power levels and associated non-reactor components, such as pumps, nozzles and control systems. This work will be carried out both in-house at such laboratories as the AEC's Argonne National Laboratory and NASA's Lewis Research Center and by industrial and university contractors.

The Los Alamos Scientific Laboratory of the AEC will continue Kiwi reactor tests through calendar year 1964. The laboratory, at the same time, will begin an increased effort in higher-powered Phoebus graphite reactors.

The 1,000-megawatt NERVA engine project, under contract to Aerojet-General Corp. and Westinghouse Electric Co., will be aimed at an experimental ground or non-flight engine system.

The major effort in the NERVA engine will be on reactor engineering and on other essential subsystems necessary to create an operating experimental nuclear propulsion engine. Those elements essential to the ground test program will be included. This revised project will require a lower level of funding, but contemplates undertaking an eventual flight system development.

The *RIFT* project, under contract with Lockheed, was directed by NASA's Marshall Space Flight Center. The joint announcement said that almost all of the $14 million of research and engineering effort already undertaken is applicable to chemical rocket systems under development.

Since no flight hardware fabrication has been started, the announcement said, this project can be terminated now without having incurred the large costs associated with flight system development. ■

Boeing Gets $60-million Lunar Orbiter Award

THE BOEING CO. will build the *Lunar Orbiter* spacecraft for NASA under a new incentive-type contract expected to exceed $60 million.

Boeing was one of five firms bidding. The others were Hughes Aircraft Co., Lockheed Missile and Space Div., the Martin Co. and Space Technology Laboratories.

The Boeing plan calls for the spacecraft to be three-axis-stabilized, use an Eastman Kodak-developed camera system and RCA power and communication subsystems.

The program provides for five spacecraft to be launched by NASA to take close-range photographs of the Moon's surface. The first flights are planned to begin in 1966. The spacecraft also will carry scientific sensors to measure such conditions as radiation and micrometeoroid density.

The *Lunar Orbiter* will complement the *Ranger* hard-landing spacecraft and the soft-landing *Surveyor.* As well as providing important scientific data about the Moon, these three projects are needed to pave the way for the *Apollo* manned lunar landing missions.

Both broad and narrow areas of the lunar surface will be photographed by the *Lunar Orbiter* camera system. These pictures will be useful in selecting the landing sites for future missions, both manned and unmanned. Photographs taken by the *Orbiter* will be transmitted by telemetry to ground receiving stations of NASA's Deep Space Network (DSN), operated by the Jet Propulsion Laboratory, Pasadena, Calif.

In addition to the on-board experiments, tracking data from the spacecraft over a period of time will provide information on the gravitational field of the Moon and its mass distribution—important in the design of lunar navigation systems. Such information is of high interest to the world scientific community as it will provide clues to the Moon's origin.

Launch of the *Lunar Orbiter* will be from Cape Kennedy aboard the *Atlas-Agena* vehicle which is capable of placing slightly more than 800 lbs. into lunar orbit.

At AAAS annual meeting . . .

Plan Advanced for Landing Probe On Mars in 1969 As Urgent U.S. Goal

Professor proposes use of Saturn IB to boost payload of several hundred pounds; Abelson indicates opposition; highlights of some other papers presented at convention generally considered subpar

CLEVELAND—A U.S. biologist has called for the United States to land a large probe on the planet Mars in 1969.

Dr. Allan Brown, professor of biology at the University of Pennsylvania, told the annual meeting of the American Association for the Advancement of Science that a significant scientific probe of the planet could be achieved at the cost of $2.47 per person in the U.S. for six years—or a total of about $2.9 billion.

Brown suggested that such a mission would lend itself to international cooperation with much greater scientific advantages and "should be more easily achieved than in any other area of space research or exploration in which both U.S. and Soviet programs are involved." He added that steps should be taken now to make this a national goal because "there is urgency in becoming prepared to launch a space probe to Mars during the 1969 period, since the surface could be sampled during spring and summer when there would be the best chance of detecting plantlife organisms."

Brown made the suggestion that the *Saturn IB* booster be adapted to carry several hundred pounds of instruments.

He said the chances of finding physiological evidence—such as specific catalysts, autotrophy, catabolic CO^2 production and growth—are greater than the prospects for morphological evidence.

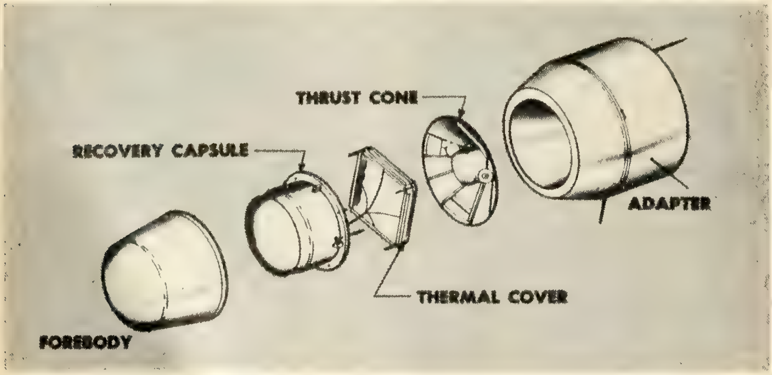
Brown termed critical the lack of knowledge about the absolute pressure of the atmosphere of Mars, needed so that a lander can be designed.

His comments followed the Washington release of a report by Dr. Gerard Kuiper of the University of Arizona that the atmosphere may be so thin that wings or parachutes could not be used for landing.

If this is true, retrorockets would have to be used to gently lower any vehicle to the surface. Scientists at the AAAS meeting said that they held Dr. Kuiper's opinion with value, but that more work will have to be done before real conclusions can be drawn. The Mars flyby set for launch in late 1964 will not carry instruments which would give this information on exact atmospheric pressure.

- **Opposition**—The call for emphasizing exobiology has been voiced by other members of the scientific community, including the Space Science Board of the National Academy of Sciences-National Research Council.

However, Dr. Philip H. Abelson, the outspoken editor of *Science* magazine, the AAAS official publication, in-

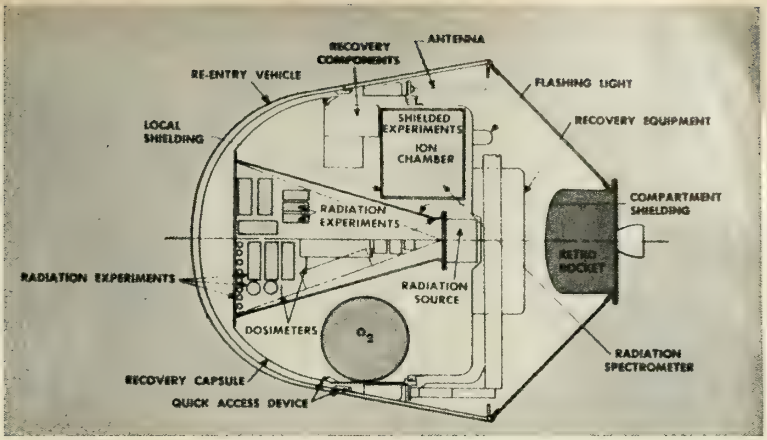


EXPLODED VIEW of Biosatellite spacecraft now scheduled for launch in December, 1965, and then at three-month intervals. NASA and General Electric engineers gave fresh details on the spacecraft at the AAAS annual meeting in Cleveland last week. (See also photograph on the next page.)

EEG Breakthrough

A CONSIDERABLE advance in the bioinstrumentation field was described to M/R by Dr. Ross Adey, scientist at the University of California at Los Angeles. Adey said that a non-implanted electrical encephalogram (EEG) to be worn in astronauts' helmets to measure brain waves is nearing completion in UCLA laboratories. The device will have six electrodes to monitor brain signals, and does not require fixing directly to the skin.

He also disclosed that tests will be made with several hundred subjects—including astronauts and pilots—to gather baseline data for computerization.



A DIAGRAM of the radiation experiment to go aboard NASA's Biosatellite spacecraft beginning in December, 1965. The package will employ a number of tissue, cell, plant and organism experiments orbited at about 150 to 200 miles altitude along with a source of radiation of less than one curie, perhaps cobalt 60 or cesium. Other craft will be adapted for pure weightlessness experiments.

by Heather M. David

dicated he would be opposed to stepping up another aspect of the space program. He said he would withhold comment until he saw how much support the Mars proposal has.

Abelson, considered a co-discoverer of plutonium, has held the position that there are other scientific, Earthbound endeavors better suited to the outpouring of national revenue.

● **Other papers**—In other sessions of what has otherwise been termed "one of the poorest programs in the past few years":

—Dr. Calvin Ward of the School of Aerospace Medicine of the Air Force Medical Div. at Brooks AFB, Tex., said that the presence of bacteria in algae systems may considerably help the growth rate of the photosynthetic plant, perhaps as much as 25%. He said that his laboratory has found that these bacteria usually comprise about 2% of the culture, and some of the strains cannot be identified.

—Dr. Dale W. Jenkins, chief of Experimental Biology for NASA's Space Sciences Div., disclosed that bedrest tests conducted in Houston hospitals to determine calcium loss from disuse of muscles showed that after three days as much as 25% of bone calcium was affected. Measurements were made with specially developed instruments which measure bone density with ±2% accuracy.

—The advantages of corn as a photosynthetic gas exchanger for long-term space travel were described by Dr. Dale N. Muss, crop physiologist for the Connecticut Agricultural Experiment Station. He said that its efficiency was about the same as algae and, although it would require a larger volume, the problem of moving the nutrient and gases through the plant mass is already solved by the nature of the plant. This might save power, he said.

—Dr. Leonard Bungers of the Martin Co. again described the chemosynthetic oxygen system which employs hydrogen-reducing bacteria to convert carbon dioxide to water and thus with electrolysis to oxygen (M/R, Sept. 16, 1963, p. 27). He disclosed that he has since found that the lower the oxygen concentration fed to the cell material, the more fat-like occlusions appear, and new forms appear as the cell divides.

—Dr. Gordon G. Goles of the University of California at San Diego and Dr. Roman A. Schmitt of General Dynamics discussed the use of instrumental neutron activation analysis (INAA) to examine meteorites. This technique 1) exposes samples and artificial standards of known composition to a flux of neutrons in a nuclear reactor, 2) observes the intensities and characteristic energies of the gamma rays given off by radioactive isotopes produced during the neutron bombardment, 3) calculates the abundances of selected elements by comparing gamma ray spectra of samples and standards. They said that this technique has disclosed regularities and correlations which were previously unsuspected, including the constancy of manganese in some chondrules. ■

Urey Sees Likelihood of Usable Water on the Moon

DR. HAROLD C. UREY, Nobel prize winner now at the University of California at La Jolla, told reporters at the AAAS meeting that it is highly probable that water in usable form exists below the surface of the Moon and that recent daytime red-glow observations on the Moon may bear out this theory.

He said that he feels sure that these observations are valid and that they would indicate the presence of water or possibly a peculiar carbon gas which contains two carbon atoms. He discounted the possibility that the glows might indicate a "hot" Moon because the light does not appear when the Moon is dark and thus is not self-illuminating.

Urey also decried the cancellation of five *Ranger* spacecraft (M/R, Dec. 23, 1963) because of the pure scientific value the instrumentation of these craft would have had. He pointed out that it was a trend that if anything went wrong in the manned program, the science programs are first to be sacrificed.

However, Urey took a less hard view of the manned program than other conservative members of the AAAS. He said that only a man can make the observations of the Moon needed for geology and biology. "The physicists are the ones who want instruments only," he said, "since they make almost all their measurements by instruments."

Orbit 'highly successful' . . .

Tiros 8's APT System Already Aids Cape Kennedy Weather Prediction

by Chris Butler

Cape Kennedy—The Air Force has found a practical application to missile launches and manned spaceflights for the APT (Automatic Picture Transmission) system carried on *Tiros 8*.

The satellite was launched by a three-stage Douglas *Delta* vehicle at 4:30 a.m. Dec. 21 and entered a highly successful orbit ranging between 436 and 468 mi. All systems were exercised within a few hours of launch and both APT and the regular *Tiros* systems returned excellent photos of cloud cover.

Lt. Col. Peter Romo, staff meteorologist of the Air Force Missile Test Center, said his office has started using the photos to make weather predictions for missile launches from Cape Kennedy.

Heart of this local operation is an APT picture ground-receiving station housed in a trailer van to provide mobility. It is operated by Detachment 11, 4th Weather Group.

Romo, who also commands the detachment, said the unit can easily be transported to remote regions of the Earth to acquire photos of cloud cover in recovery areas for manned space flights. He added that lack of reporting stations in some areas of the world would create gaps in knowledge required by planners of Dept. of Defense support for manned orbital flight.

- **Ground station deployment**—The ground station at Patrick AFB, Fla., is only one of many located around the world to receive the stream of cloud-cover photos transmitted when the APT system is programmed to operate. A large portion of these stations are owned and operated by DOD forces in the United States and abroad. Others are operated by NASA and some foreign governments.

Tiros 8 was scheduled to perform a dual mission by extending the normal *Tiros* program and by exercising the APT system designed by RCA for the second-generation, polar-orbiting *Nimbus* meteorological satellite. The APT system had been ground-tested for picture quality, transmission and reception, frequency shifts and the Doppler effect.

The APT system replaced one of the two TV cameras normally carried on *Tiros* satellites to record and relay cloud-cover pictures back to Earth for use by weather forecasters. *Tiros* cameras have returned nearly 300,000 pictures since the first *Tiros* was launched April 1, 1960, and more than 80% of these have been useable.

These photos are made with a 500-line, half-inch vidicon tube and a wide-angle lens. Up to 32 pictures are stored on tape and transmitted in a three-minute period on ground command. Receipt and reproduction of these *Tiros* photos has required elaborate and expensive equipment.

- **Low-budget**—The APT system brings such weather forecast pictures within the reach of many smaller nations because it demands only simple and relatively inexpensive equipment. Total cost of such equipment runs to about $30,000.

The 24-lb. airborne APT subsystem consists of a sensory housing, which contains the vidicon-camera and associated electronics, a video detector with timing and switching circuitry, power converters and an FM transmitter.

The APT vidicon-camera system has a wide-angle lens and a 1-in. vidicon tube with an 800-line scan to record the photos. These are transmitted directly by slow scan before the tube face is "wiped" and another picture is recorded for transmission.

Eight seconds is required to prepare, expose and develop the picture. Transmission takes another 200 seconds, permitting ground stations within range to receive up to three pictures during each *Tiros*-APT pass.

A 5-watt transmitter broadcasts the signal on the 136-mc. telemetry band; it can be received on a 13-db helix antenna. The 0.25-sec. scanning time per line is compatible with standard 240-rpm facsimile equipment.

Abe Schnapf, *Tiros* program manager for RCA, said signals from the APT system can be stored on any tape recorder and fed back later into the facsimile equipment, insuring users against loss of picture if the facsimile equipment should experience mechanical or electronic difficulties during satellite transmission.

- **APT plans**—Initial plans by Goddard called for the APT system to be operated on a restricted basis for the first two days. Pictures were scheduled to be taken only on the fourth and fifth orbits as the satellite crossed the eastern part of the United States on a northwest-to-southeast path.

The program for the APT system was to be set each day by a ground station in Alaska. Reception was scheduled at stations located at Goddard Space Flight Center, Md.; RCA Astro-Electronic Products Div., Princeton, N. J.; Wallops Island Station, Va.; U.S. Weather Bureau, Suitland, Md.; U.S. Army Electronics R&D Laboratories, Ft. Monmouth, N.J.; Fairchild-Stratos Corp., Bayshore, L. I.; and the Air Force Cambridge Research Laboratory, Cambridge, Mass.

Robert Rados, *Tiros* program manager for Goddard, said success in the first two days of testing probably would result in activating the APT system operation for stations in many parts of the world. The record-and-transmit program would be set in the satellite from ground stations at the Pacific Missile Range, Wallops Island, Va., and Alaska.

Receiving stations are operated by the Weather Bureau in many parts of the United States. U.S. military services have similar stations in many parts of the world and international stations are located at Melbourne, Australia; Malvern, England; Toronto, Canada; with the International Indian Ocean Expedition; and in France.

Next flight of the APT system will come in the first quarter of 1964, when the first *Nimbus* is launched at the Pacific Missile Range. The initial *Nimbus* will use conventional solar-cell panels for power, but the third in the five-shot series will fly with an isotopic power supply system.

Goddard spokesmen said at a preflight briefing that work is under way to extend the 800-hour life of the APT camera to 2,500 hours in order to provide a better return on the investment when the system becomes operational on *Nimbus*.

The next *Tiros* satellite launched will be of the "wheel" configuration. It is scheduled to carry two standard *Tiros* TV camera systems to extend the program of photographing cloud cover from space and to provide a complete test of the "wheel" concept for the weather satellite. ■

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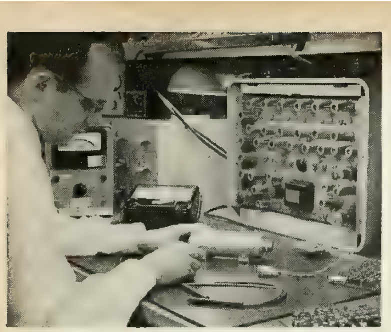

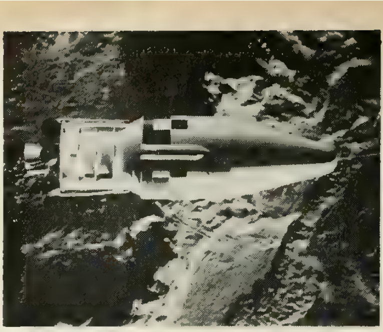

Here, at Lockheed Missiles & Space Company's Space Communications Laboratory, scientists are re-investigating the possibility of using the moon to facilitate earth communications. Possibilities for the use of the moon as a relay station for earth-to-earth communications have been largely neglected because the moon's shape and rugged surface greatly distorted a return signal. But Lockheed research into the extension of communications on difficult communication channels, using techniques applicable to dispersive time variant channels, is making significant inroads into this problem.

Another area receiving intense study at Lockheed is satellite tracking of deep space probes. Since tracking accuracy depends greatly on stations being as far from each other as possible, while retaining line-of-sight communications, Lockheed is studying the use of two earth-orbiting satellite tracking stations, 8000 miles apart. Not only would great accuracy be gained by the separation, but it would be further enhanced by the positioning of the stations above the earth's atmosphere, thus eliminating atmospheric distortion.

Examples of other research projects being pursued by Lockheed in the communications area include: Random multiplexing, satellite readout techniques, scatter communications, radar mapping, submarine tracking, modulation of optical energy, communications over multipath channels, and learning systems.

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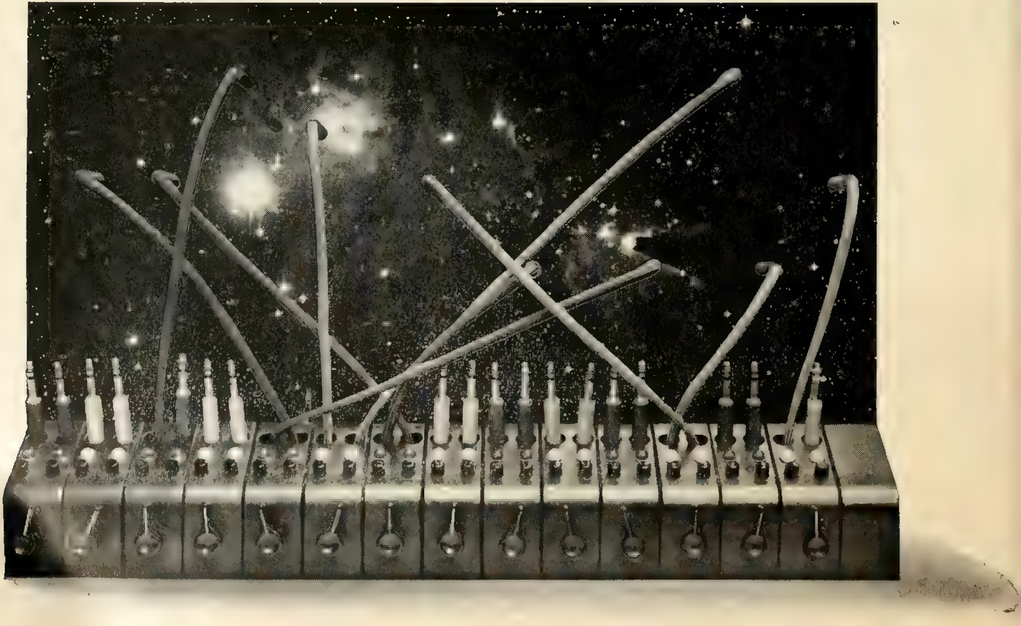

Technical Countdown

ELECTRONICS

Natural Lasering in Space?

Use of a laser-like amplification medium that may exist in interstellar space could provide a new avenue of approach to determining the existence of intelligent signals transmitted from other planets. The amplifying source, suggested Dr. Fred Johnson speaking recently before the

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Scientists at the University of Michigan's Electron Physics Lab have perfected a device capable of solving Poisson equations. The analog-computer-type instrument was originally designed to find the paths electron streams would take in new electron tubes to improve their performance. The unit can solve similar equations in other fields such as ion rocket engine design, re-entry conditions and air foil flow. The cell consists of a board-like tracing table on which the tube's electric field is represented, a myriad of wires leading from it to panels for adjusting the field and a path-tracer connected to an analog computer. Prof. Joseph E. Rowe, director of the lab, says the instrument has an acceptable accuracy of 2 to 3%.

French Project Own Warning Net

France is now planning to build a ballistic missile warning system of its own to be linked to the U.S. *BMEWS* network. French officials are confident that the system could be built within three years, using the existing Aquitaine radar as its basis. It would be coupled with the Mirage bomb or the French IRBM's (*SSBS*) and provide a reaction time of five minutes.

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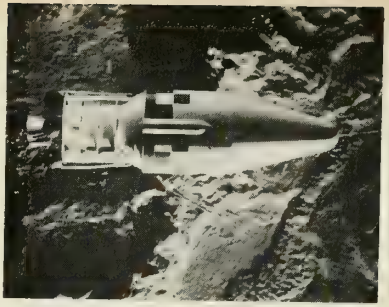

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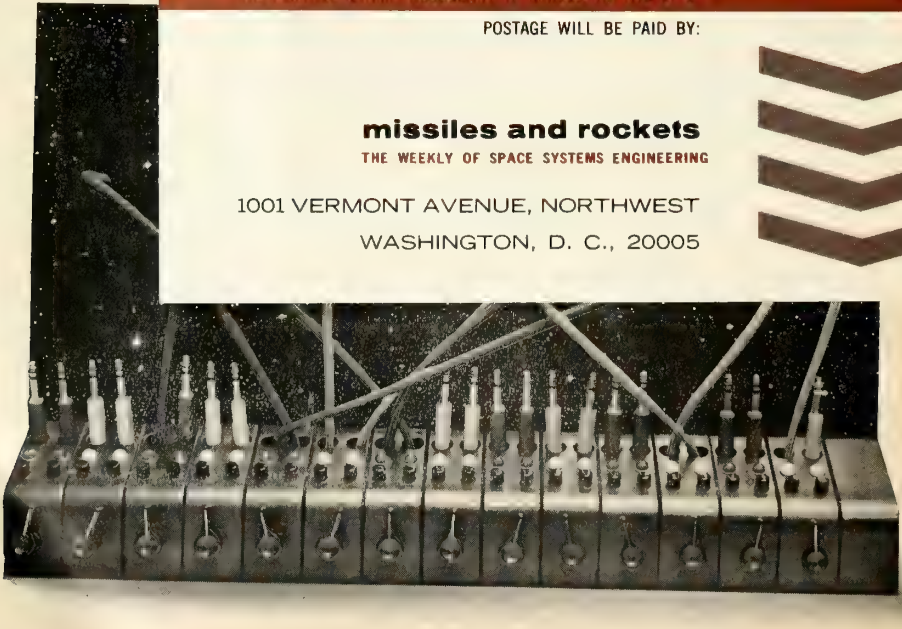

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TRUMP To Use Single-Plane Control

A single-plane attitude control system will be developed for the Air Force's Target Radiation Measurement Program (TRUMP) by Whittaker Controls and Guidance Div. of Telecomputing Corp. TRUMP will employ a spin-stabilized *Nike-Javelin* research rocket. Attitude will be controlled pneumatically by a cold-gas attitude control system electronically actuated by a miniaturized attitude reference system. The control, electronic and battery pack will be integrated.

Microelectronic Device Delivered for Testing

A microelectronic version of a missile decoder output module will be used in test programs to prove feasibility of replacing conventional circuits in existing equipment. Developed by General Electric's Light Military Electronics Dept., the decoder was delivered to the Applied Physics Laboratory of Johns Hopkins University. The unit contains about 95 modules of 34 different types with each module consisting of one to four hybrid thin-film circuits mounted on glass substrates. The digital-to-analog circuits contain thin-film resistors of 0.5% values with temperature coefficients of less than ±50 ppm/degree C. Thin-film capacitors up to 10,000 pF were used with working voltages of 25 v. Active semiconductor devices are attached through thermocompression bonding. GE spokesmen say the system either maintains or improves upon original values with only ⅓ the size. The contract called for three units built in a manufacturing facility.

Poisson Equation Solver Perfected

Scientists at the University of Michigan's Electron Physics Lab have perfected a device capable of solving Poisson equations. The analog-computer-type instrument was originally designed to find the paths electron streams would take in new electron tubes to improve their performance. The unit can solve similar equations in other fields such as ion rocket engine design, re-entry conditions and air foil flow. The cell consists of a board-like tracing table on which the tube's electric field is represented, a myriad of wires leading from it to panels for adjusting the field and a path-tracer connected to an analog computer. Prof. Joseph E. Rowe, director of the lab, says the instrument has an acceptable accuracy of 2 to 3%.

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PROPULSION

Submerged Liquid Rocket Fired

A liquid-fueled rocket was started, run silently, stopped, restarted and run twice again 30 feet under San Francisco Bay by personnel from Aerojet-General's Liquid Rocket Plant. A 17,000-lb.-thrust, pressure-fed *Corporal* rocket engine was run for 6.2 seconds, shut down and operated again for 8- and 1-second periods in the test. The program, under Robert C. Truax, is ultimately aimed at massive booster launchings from the sea. The initial investigations are being funded by NASA.

UTC Investigates Propellant Pellets

Higher energy ingredients may be possible in solid rockets if a pellet approach at United Technology Center works out. Pelletizing oxidizers is not new to the solid propulsion field and work has been in progress at various laboratories for some years. The UTC program is being funded by NASA's Marshall Space Flight Center. Oxidizer pellets are placed in layers inside a rocket casing and a slurry fuel is then poured over them. Several motors using the pellet concept have been fired by UTC.

Lockheed's 156-in. Cases to Excelco

Excelco Developments, Inc., will fabricate the 156-in. motor case segments for Lockheed Propulsion Co. to be used in the large solid rocket feasibility study at Redlands, Calif. The motor is designed for 1-million-lbs. thrust and will test a jet tab system for controlling thrust direction. The Lockheed case contract totals approximately $767,000.

SPACE MEDICINE

Chimp Confinement Successful

Lockheed Missiles and Space Co. has completed an 8-day space simulation test in which a chimpanzee was confined in a USAF test complex vacuum chamber. The capsule, built by Lockheed, was equipped with a Garrett Corp. environmental control system, and monitoring equipment was furnished by Holloman Aeromedical Research Laboratory. The chimp lost less than a pound during the confinement and had "remarkably stable" heart rate, respiration and body temperature.

Prisoners Volunteer to Test Space Food

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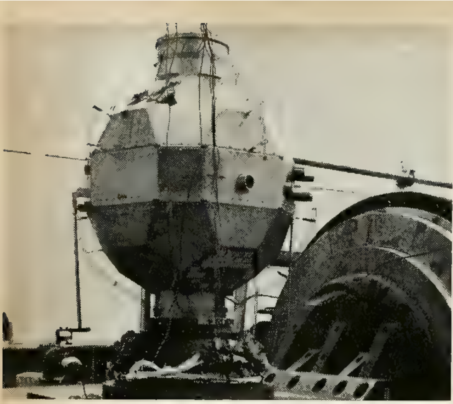


TESTING dynamic prototype of satellite.

'Off-the-Shelf' Injun IV Set to Go in Early '64

Scout-borne satellite to study solar particle effect on Earth's atmosphere; also to furnish re-entry, orbit calculation data

by William Beller

ACTING LIKE a three-dimensional compass needle, the *Injun IV* satellite is to be launched early this year to discover how solar particles affect the Earth's atmosphere.

To be lofted into a near polar orbit by a *Scout* vehicle from the Pacific Missile Range, the spacecraft is expected to reach an apogee of 2,500 km and a perigee of 500 km.

Beyond its purely scientific value, the *Injun IV* experiments may provide data useful for calculating satellite orbits and making re-entry studies of hypersonic vehicles, Dr. J. A. Van Allen, principal investigator on *Injun IV* and professor of physics at the State University of Iowa, said in an exclusive interview with MISSILES AND ROCKETS.

A second objective is to follow the long-time decay of the intensity of the electrons injected by the Starfish high-altitude nuclear explosion over Johnston Island in the South Pacific, July 9, 1962.

A third is to study the arrival of cosmic rays during the International Years of the Quiet Sun, from Jan. 1, 1964 to Dec. 31, 1965.

In the overall picture, an attempt is being made to find out why the Earth's atmosphere behaves as it does. The entire atmosphere subsided over the past few years, for instance, possibly in part caused by lessened solar corpuscular radiations, Van Allen believes.

- **Assembly-line satellites**—One sign of the way satellite technology is settling down is the use for *Injun IV* experiments of a standard satellite structure, developed by Bendix Systems Div. of Ann Arbor, Mich.

The company calls its space package a multi-purpose "utility" satellite. It offers low cost and the ability to be launched by common NASA or military boosters. For example, a *Scout* vehicle with a 34-in.-dia. heat shield is said to be able to place a utility satellite with 150 pounds of payload into a 350-mi. circular orbit. Or a multiple launch could be made with larger boosters such as *Thor Delta, Minuteman* and *Polaris.*

- **Balloon goes piggy-back**—The *Injun IV* experiment package includes a 12-ft.-dia. inflatable mylar balloon in a cylinder housed within the satellite. Once in orbit, the balloon with its beacon will be ejected, thereby falling into essentially the same orbit as the utility satellite. Baker-Nunn cameras will track the two satellites for orbital data.

The total payload sent aloft will be about 56 pounds plus 17 pounds for the balloon and other equipment. The scientific payload is being developed by the State University of Iowa under contract to NASA's Langley Research Center, while the balloon payload is being developed by the Center itself.

The Center, in fact, is actively supervising the entire *Injun IV* effort, headed by Claude W. Coffee, Jr., Langley project manager. William A. Whelpley manages the State University's part of the project, which is sometimes called *Injun Explorer* to differentiate it from the *Air Density Explorer* or inflatable sphere portion.

The experimenters will try to correlate the balloon drag with the amount of corpuscular energy delivered through the upper atmosphere. In other words, some scientists believe that corpuscular heating of the atmosphere on some occasions is significant in increasing the temperature of the atmosphere at altitudes of the order of 100-500 km., in increasing the scale height, and hence in increasing the air density at such altitudes. Luigi G. Jacchia, Smithsonian Astrophysical Observatory, is credited with building up a presumptive case for this theory.

EXPERIMENTS FOR INJUN IV

Corpuscular Energy Downflux (also trapped flux and upflux)—(a) Two CsI-photomultiplier tube detectors, one at $\propto = 90$ degrees, one at $\propto$ approximately 125 degrees. CsI $\leq$ 10 mg/cm^2. Used as quasi-d.c. instrument for total energy flux. Zero foil thickness. Constant anode current used to servo high voltage. Dynamic Range: 0.1 to 5,000 ergs/cm^2 sec. sterad.

(b) Four CdS detectors. Bare crystals used as quasi-d.c. energy flux instruments. One at $\propto = 90°$, two at $\propto = 125°$ (one with and one without sweeping magnet), one at $\propto = 160°$. Dynamic Range: 1 to 5,000 ergs/cm^2 sec. sterad.

(c) Four 213 Geiger tube directional detectors. Window thickness 1.2 mg/cm^2. A special aperture array to cover a lune from $\propto = 0°$ to $\propto = 180°$ in four segments centered at approximately $\propto = 35°, 90°, 125°$ and $160°$. Electrons of $E > 40$ keV, protons of $E > 500$ keV. Individual particle counting. Dynamic Range: 1 to 10^6 particles/cm^2 sec. sterad.

Protons and Alpha Particles in Outer Zone and Solar Cosmic Ray Events—One thin p-n junction detector at $\propto = 90°$. Cycled between two depletion depths. Two electronic bias levels. Separate determination of protons and alpha particles of energies exceeding 0.5 and 1.5 MeV. Individual particle counting. Dynamic Range: 1 to 10^6 particles/cm^2 sec. sterad.

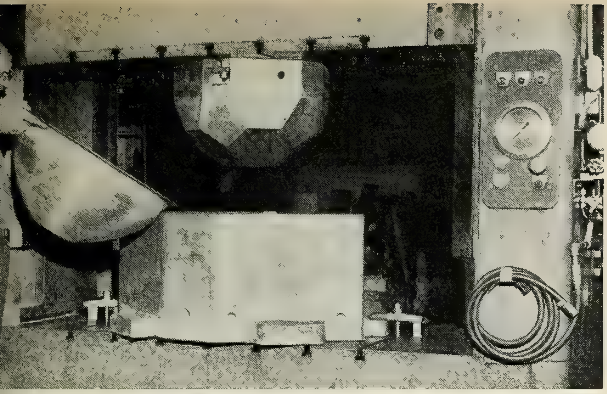
Long Term Decay of Starfish Radiation Belt—One heavily shielded SpB Gieger tube similar to those in *Injun I, Explorer XII* and *Injun III.*

General Radiation Zone Monitoring and Solar and Galactic Cosmic Ray Intensities—(a) One 302 G.M. tube (0.6 g/cm^2 shield) (b) One 112 G.M. tube shielded as in *Explorer VII.*

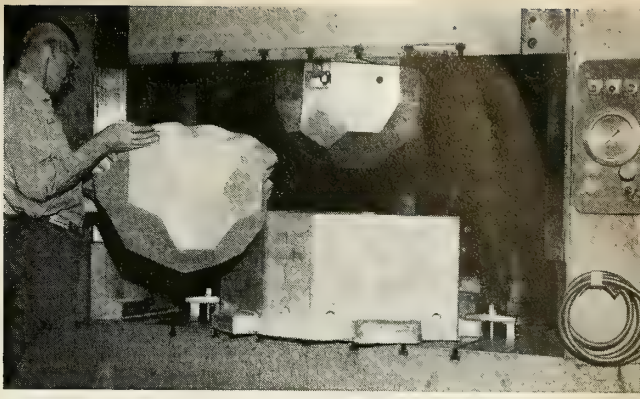
Magnetic Aspect—Two-axis Schonstedt magnetometer for determination.

Solar Aspect—One GSFC digital type solar aspect indicator.

Ionospheric Electron Density—One electron probe by AFCRL.



INSTALLING SPUN aluminum shell in hydraulic stamping die.



REMOVING STAMPED shell from die.

Van Allen points out, though, that direct evidence for this belief is lacking and "it is conceivable that the necessary heating is not due to the direct absorption of energetic particles, but might be due to hydromagnetic waves or other processes not yet proposed." The scientist, nevertheless, seems to lean toward Jacchia's contention and thus is setting up *Injun IV* in an attempt to validate the theory.

The energies given up by solar particles as they impinge upon the Earth's atmosphere are 1% light and 99% heat. "It's like playing a blowtorch on the atmosphere," says Van Allen. "We first want to get a one-to-one correlation that corpuscular heating is directly connected with the change in atmospheric drag," he continued. "Then we want to get quantitative observations to complete our knowledge of this phenomenon. And thirdly, we want to get data on the transfer of heat from one point to another in the atmosphere."

- **Magnetically stabilized**—*Injun IV*, a natural successor to *Injun III* launched Dec. 13, 1962, is part of a continuing study of the charged particles in the Earth's auroral zones. A big bar magnet will keep *Injun IV* oriented parallel to a magnetic line of force. This method was used on *Injun III* and "it worked fine," Van Allen observed. Requiring no power and entailing only a passive device, "the satellite may be considered a three-dimensional compass needle," he said.

This magnetic stabilization method was originally used on a *Transit* navigation satellite.

The reason for aligning the satellite cross-axis with the Earth's magnetic field stems from the fact that the magnetic vector is the physically important direction in particle investigations. The *Injun IV* experiments are interested in the dumped particles—that is, those that will intercept the Earth. These cut the magnetic lines of force or the magnetic field other than at right angles, and consequently spiral toward Earth. Thus the experiment is tied in with the production of visible aurora.

On *Injun III*, at high latitudes, a photon counter plus collimator pointed toward Earth and parallel to a magnetic field line, while a particle counter looked into space at an angle of 180 degrees from the photon counter. In this way, the corpuscular energy delivered to the atmosphere was correlated with the aurora glow near the poles. Van Allen noted that the photon detector was so sensitive that during the experiment pips were detected from photons emanating from both New York and Boston.

- **Versatile satellite**—The Bendix utility satellite can be tailored to meet the needs of the individual experimenter. Each unit has a nominal 24-in.-dia. honeycomb deck completely free for mounting experiments. Equipment can be mounted above or below the deck, or additional decks may be added for extra layout space. View ports may be placed as desired at any location.

The shell of the satellite (excluding the 10-sided belt area) is formed by 30 hexagonal and pentagonal panels with a total flat-surface area of about 1,500 sq. in. This configuration, which has excellent structural integrity, simplifies the application of solar cells.

The omni-directional array provides approximately 20 watts of continuous power for a 24-in.-dia. satellite with typical surface utilization. The variable-height center girth belt is provided for instrument viewing area, but could be used in some experiment configurations to carry additional solar cells for increased power.

Low cost is achieved through simplicity of design and the use of time-saving fabrication techniques. The aluminum shells are formed by a single stamping operation, and use of assembly fixtures reduces assembly time and provides interchangeability of parts. The end result is delivery of a qualified structure that is essentially "off-the-shelf."

- **Design of telemetry**—The telemetering of data from *Injun IV* will be through two pulse-code modulated systems, one for real-time transmission of data, the other for data that had previously been tape-recorded. The systems will be served by the same data encoder that will handle digital (pulse number modulated) and analog inputs. The tape recorder and its associated data link will be actuated through radio commands from ground stations.

A tentative telemeter assignment results in a bit rate of 120 per second if a frame rate of one per second is assumed. The tape recorder gives a 26:1 speed-up ratio in the reproduce mode; therefore, the bit rate on tape playback is 3,120 bits per second.

During the powered-flight phase, *Injun IV* will provide a wide-band radio-frequency link for use by Goddard Space Flight Center in the telemetering of vehicle performance data.

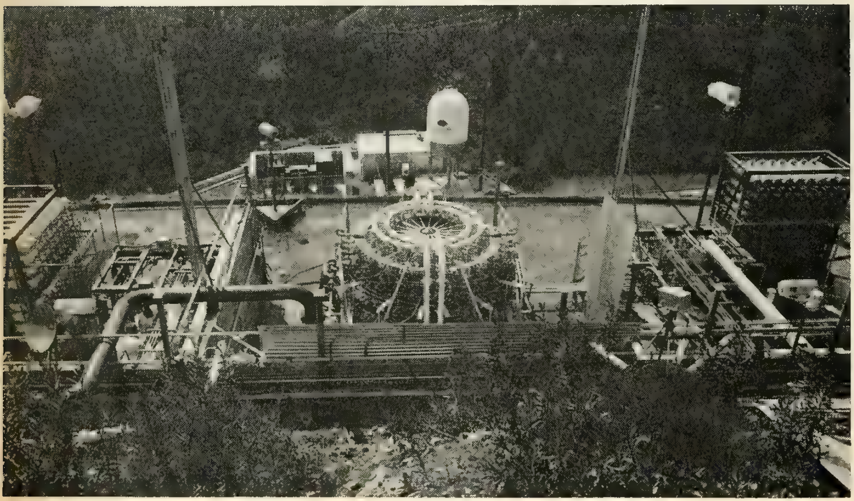
- **Power subsystem**—The power source for *Injun IV* will consist of six panels of silicon N-on-P solar cells. Each panel will be capable of delivering an output of greater than 8 watts when illuminated from the normal direction by one solar constant.

Continuous power for the detectors and beacon transmitter along with the command system will be from a central converter. Another converter will be used to provide power for the high-power transmitter tape recorder. A third power converter will be used to provide power for the operation of an Air Force Cambridge Research Laboratory experiment.

Thermal control will be obtained through passive means. The thermal environment will be determined by the average ratios of solar absorbtivity to black body emissivity of the outside shell of the spacecraft. This ratio will be determined by the application of surface coatings and painted areas. ■

Test Complex Simulates Polaris Re-entry Heat

Hydrogen jet heater at Lockheed's Santa Cruz installation is providing reliable data on char-forming ablative bodies



by Joseph N. Steinmetz, Jr.
Design Specialist
Lockheed Missile & Space Co.
Sunnyvale, Calif.

A TEST COMPLEX designed to simulate re-entry thermal gradients in *Polaris* heat-sink type shell materials is now providing significant data on char-forming ablative body surfaces.

The hydrogen jet heater (HJH) at Lockheed's Santa Cruz Test Base in the San Francisco Bay area has been used for the past two years to produce surface recession of *Polaris* re-entry shell structures.

- **Heating mechanism**—The heater consists of clusters of up to several hundred burners, arranged to conform approximately to the exterior shape of the test specimen. The outer surface of full-scale or portions of re-entry bodies can be enveloped by myriads of concentrated flame cones resulting from the combustion of gaseous hydrogen and oxygen.

The combustion may be controlled to produce varying rates of surface recession from zero to the current maximum of about 0.012 in. per second. The rate is adjusted and programmed to match the predicted re-entry recession of the specimen being tested.

In the HJH experiments, it has been noted that when the surface recession history in tests corresponds to that in actual flight, the temperature gradient through the shell is also very similar. The thermal gradients produce stresses that can cause failure of the composite shell structure if it is not properly designed or bonded.

By performing shell tests on the ground in the HJH, it is possible to perform complete post-test inspection—including sectioning—so that anomalies, if they exist, can be examined in detail. Because of this, the structural analyst is assisted in determining the adequacy of design in early stages. This is also important because it is impossible to inspect re-entry bodies lost at sea during actual flights.

Lockheed thermodynamicists are currently studying re-entry shell recession histories through use of ablation gages on *Polaris* shells. This information is compared with ground test data from the shells tested in the HJH to confirm adequacy of the HJH design. Some shell anomalies from thermal gradients were experienced early in the *Polaris A3X* program, but the tactical design has been tested thus far without any evidence of failure.

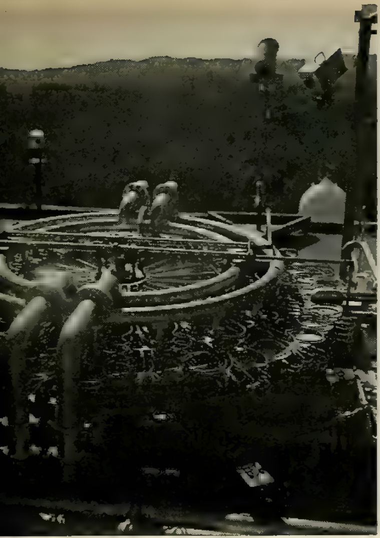
Successful experiments have also been performed in which large portions of re-entry body shells were deliberately not bonded to the liner—then subjected to exit phase heating and recession, coast phase cooling, and re-entry phase heating and recession in sequence.

Programmed mechanical loads were also applied to the shell to add to test realism. The purpose of this experiment was to assist Lockheed structural experts in determining whether bond failure is within tolerable limits. Other heating methods will suffice for some studies of char-formers, such as plasmas for material studies, rocket engines for nose cone work, and hot gas flow for some moderate trajectories, but only the HJH has been found satisfactory for approximating the thermal shock on full scale cylindrical shells and flares associated with *Polaris* re-entry environments.

Chemical rockets continue to be useful for simulating the very high rates of recession associated with vehicle noses, but the rocket is not versatile and will not conform to large surface areas and body shapes.

- **Facility description**—The HJH facility includes huge manifolds built to convey water and gasses. These manifolds also hold the burners in position conforming to the shape of the shell being tested. Large quantities of water are circulated through the burner head and jacket so that it will survive its own destructive environment (M/R, Feb. 20, 1961, p. 24).

The burner itself was developed under cost-plus-fixed-fee contract to Lockheed Re-entry Systems and the Navy by Hammon Precision Equipment Co. in Oakland, Calif. Manifolding, servo systems, control consoles, instrumentation, auxiliary systems and thermal



tests themselves are conducted by the engineers and technicians of Lockheed's Santa Cruz Test Base. Test requirements and test program management is handled by Lockheed's Re-entry Systems engineers in Sunnyvale, Calif.

The major technological roadblock to large scale thermal simulation in this manner was designing the burner cooling system. Many initial experiments were unsuccessful because of backfiring and thermal damage to the Hammon burner. It must survive in its own environment, which is created essentially by gangs of 2-in.-sq.-headed cutting torches with 2-in.-sq. heads whose flames impinge upon the test specimen.

The hot exhaust gasses must exhaust rearward along the burner heads and delivery jacket. A breakthrough occurred in the form of a super-cooling system, evolved after several months development. It affords reliable, repeatable performance for any required period of heating. The burners may be throttled as required to produce pulse shapes, and heating may also be regulated to provide recession gradients from front to rear, as required to match flight performance.

In earlier work on heat sink materials, it was discovered that the HJH can provide heat rates in excess of 650 Btu/sq. ft./sec. on low temperature calorimeters. It does this in highly controllable fashion, and with accuracies within a few percentage points, especially when an electro-hydraulic servo system for gas flow control is used to provide temperature error correction.

- **Surface recession control**—In the case of HJH tests of charring ablators, the control is more difficult because the basic processes are more complex and, in addition, it is more difficult to take precise measurements of the transient temperature and recession event. Because of this, the schedule of hydrogen and oxygen pressures to be followed is ususally predetermined and no feedback is attempted for control purposes. Recorded data and post-test inspection show that this procedure provides reasonably good approximation of the desired simulation.

Theoretical explanation of the HJH processes in simulating surface recession would be difficult, and perhaps impractical, to perform quantitatively. Charring ablators involve several modes of heat blockage that all vary with time, not to mention the complexities of the combustion processes, which also vary with time and the temperature of the test specimen. Analysis of the process is not essential, however, to successful utilization of the HJH.

In order to determine whether the shell structure will survive the stresses associated with the re-entry thermal environment, it is required that the predicted surface recession and thermal gradients be reproduced to account for the major effects. The HJH affords reasonably good reproduction of these factors, but it will not adequately simulate the gas dynamic pressure forces associated with re-entry, Mach number and enthalpy, such as would be required to qualify as a true aerodynamic simulator.

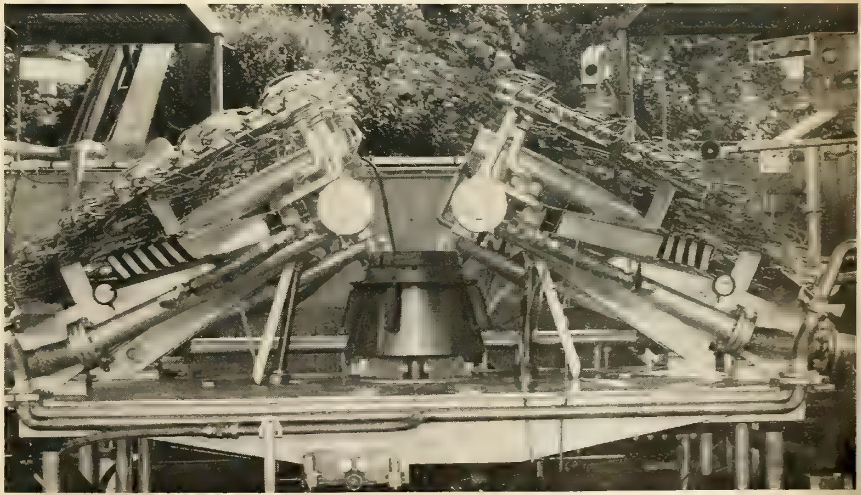
The only true experience available today for *Polaris* is obtained from actual re-entry; however, as was mentioned earlier, a great problem arises out of the fact that the structure is not recovered. Thus, there are many anomalies such as buckling, bond failure, cracks, delamination, distortion and broken areas that, if they occurred, would probably go undetected.

- **Gas dynamics forces**—Since the gas dynamics forces on the outside of the shell are of order of magnitude of only an atmosphere or two during re-entry, the stresses from this effect are small in proportion to the thermal stresses. It may be concluded, then, that the HJH will in itself achieve the most significant structural effects.

These effects can be supplemented, however, by auxiliary mechanical and vacuum loading techniques to help account for aerodynamic and deceleration forces. Stresses caused by these factors are superimposed upon the stresses caused by heating to provide more realistic re-entry simulation.

The HJH also has been used to assist in evaluating the seriousness of structural damage caused by simulated sharp pulses associated with enemy counter-attack. When such damage is suspected of being catastrophic, the specimen may be subjected to the desired heat pulse to observe whether the thermally induced stresses further cripple the structure. ■

OPPOSITE PAGE: Burner assembly surrounds a full-scale re-entry structure, with nose at top center of assembly. ABOVE: Clustered burners apply simulated re-entry heat to a 16-in. length of re-entry cylinder structure. Water-cooled plates at top apply compression loading to simulate deceleration forces during re-entry. RIGHT: Burner clusters lift away to permit access to specimen. Only a small length of flare, including a joint, was tested here.



With $1.5 billion . . .

Lockheed Again Top DOD Contractor

LOCKHEED AIRCRAFT Corp. held its grip on first place among the top 100 prime contractors for DOD in Fiscal Year 1963, repeating its 1962 showing. General Dynamics Corp., second last year and first in FY 1961, dropped to fourth, while the Boeing Co. moved from third into runnerup position.

McDonnell Aircraft Corp. continued a steady climb, jumping to ninth place from 17th in FY '62 and 23rd in Fiscal '61.

The first five primes all did more than $1 billion worth of business with DOD in FY '63. General Electric Co. added to the billion group over FY '62. General Motors Corp. dropped from the top 10 to 11th, replaced by Sperry Rand Corp., which also dropped one position.

The 100 largest contractors increased their percentage share of the DOD total by 1.6% to 73.9%, although this still amounted to 0.3% less than in Fiscal '61.

DOD pointed out that the percentage for the first 25 firms was lower than in any year since 1962. The top 100 firms were awarded $19.0926 billion of the DOD total expenditure of $25.834 billion, approximately the same percentage as in the years prior to 1962.

DOD LIST OF FY 1963 100 TOP PRIME CONTRACTORS

RANK	COMPANIES	MILLIONS OF DOLLARS	PERCENT OF U.S. TOTAL	CUMULATIVE PERCENT OF U. S. TOTAL
	U. S. TOTAL	$25,834.0	100.0%	100.0%
		19,092.6	73.9	73.9
1.	Lockheed Aircraft Corp.	1,517.0	5.9	5.9
2.	Boeing Co.	1,356.3	5.2	11.1
3.	North American Aviation, Inc.	1,062.4	4.1	15.2
4.	General Dynamics Corp.	1,033.2	4.0	19.2
5.	General Electric Co.	1,021.2	4.0	23.2
6.	Martin Marietta Corp.	766.8	3.0	26.2
7.	American Telephone & Telegraph Co.	578.6	2.2	28.4
8.	United Aircraft Corp.	529.9	2.1	30.5
9.	McDonnell Aircraft Corp.	497.0	1.9	32.4
10.	Sprery Rand Corp.	445.5	1.7	34.1
11.	General Motors Corp.	444.0	1.7	35.8
12.	General Tire & Rubber Co.	424.6	1.6	37.4
13.	Grumman Aircraft Engineering Corp.	390.5	1.5	38.9
14.	Douglas Aircraft Co.	361.1	1.4	40.3
15.	Radio Corp. of America RCA Institutes, Inc.	328.6	1.3	41.6
16.	Westinghouse Electric Corp.	322.6	1.3	42.9
17.	Hughes Aircraft Co.	312.9	1.2	44.1
18.	Raytheon Co.	294.9	1.1	45.2
19.	Bendix Corp.	290.3	1.1	46.3
20.	International Telephone & Telegraph Corp.	265.5	1.0	47.3
21.	Avco Corp.	253.1	1.0	48.3
22.	Thiokol Chemical Corp.	238.6	0.9	49.2
23.	Ford Motor Co.	227.7	0.9	50.1
24.	Northrop Corp.	222.9	0.9	51.0
25.	Newport News Shipbuilding & Dry Dock Co.	221.0	0.9	51.9
26.	L-T-V, Inc.	205.9	0.8	52.7
27.	International Business Machines Corp.	203.3	0.8	53.5
28.	F M C Corp.	199.1	0.8	54.3
29.	Litton Industries, Inc.	197.8	0.8	55.1
30.	Republic Aviation Corp.	196.8	0.7	55.8
31.	Chrysler Corp.	186.2	0.7	56.5
32.	Hercules Powder Co.	182.7	0.7	57.2
33.	Minneapolis-Honeywell Regulator Co.	170.0	0.7	57.9
34.	Merritt-Chapman & Scott Corp.	169.9	0.6	58.5
35.	General Telephone & Electronics Corp.	162.6	0.6	59.1
36.	Standard Oil Co. (New Jersey)	155.5	0.6	59.7
37.	Pan American World Airways, Inc.	154.5	0.6	60.3
38.	Textron, Inc.	151.2	0.6	60.9
39.	Collins Radio Co.	144.3	0.6	61.5
40.	General Precision Equipment Corp.	131.4	0.5	62.0
41.	Texaxo, Inc.	120.5	0.5	62.5
42.	Standard Oil Company (California)	116.6	0.4	62.9
43.	Thompson-Ramo-Wooldridge, Inc.	106.4	0.4	63.3
44.	Curtiss-Wright Corp.	98.4	0.4	63.7
45.	Continental Motors Corp.	97.2	0.4	64.1
46.	Morrison-Knudsen & Associates	84.4	0.3	64.4
47.	Studebaker Corp.	83.3	0.3	64.7
48.	Burroughs Corp.	77.5	0.3	65.0
49.	Aerospace Corp.	75.5	0.3	65.3
50.	Goodyear Tire & Rubber Co.	72.7	0.3	65.6
51.	Massachusetts Institute of Technology	70.8	0.3	65.9
52.	Bethlehem Steel Corp.	68.4	0.3	66.2
53.	Hayes International Corp.	67.1	0.3	66.5
54.	Shell Caribbean Petroleum Co.	66.5	0.3	66.8
55.	International Harvester Co.	66.3	0.3	67.1
56.	Olin Mathieson Chemical Corp.	65.8	0.2	67.3
57.	Johns Hopkins University	65.5	0.2	67.5
58.	Socony Mobil Oil Co.	64.2	0.2	67.7
59.	Lear-Siegler, Inc.	61.0	0.2	67.9
60.	Magnavox Co.	57.7	0.2	68.1
61.	American Machine & Foundry Co.	57.1	0.2	68.3
62.	Universal American Corp.	56.3	0.2	68.5
63.	Garrett Corp.	55.7	0.2	68.7
64.	Kiewit (Peter) Sons' Co.	54.1	0.2	68.9
65.	Kaiser Industries Corp.	49.2	0.2	69.1
66.	Du Pont (E. I.) De Nemours & Co.	47.9	0.2	69.3
67.	Standard Oil Co. (Indiana)	45.6	0.2	69.5
68.	Kaman Aircraft Corp.	44.9	0.2	69.7
69.	Ryan Aeronautical Co.	44.2	0.2	69.9
70.	White Motor Co.	44.0	0.2	70.1
71.	System Development Corp.	43.9	0.2	70.3
72.	Continental Oil Co.	43.1	0.2	70.5
73.	Sverdrup & Parcel, Inc.	42.3	0.2	70.7
74.	Western Union Telegraph Co.	41.5	0.2	70.9
75.	Richfield Oil Corp.	39.8	0.2	71.1
76.	Sinclair Oil Corp.	38.4	0.2	71.3
77.	Vitro Corp. of America	37.0	0.2	71.5
78.	Gilfillan Corp.	37.0	0.2	71.7
79.	Eastman Kodak Co.	36.8	0.1	71.8
80.	Bath Iron Works Corp.	34.6	0.1	71.9
81.	American Bosch Arma Corp.	33.8	0.1	72.0
82.	Union Carbide Corp.	33.6	0.1	72.1
83.	Day & Zimmerman, Inc.	33.3	0.1	72.2
84.	Mitre Corp.	33.1	0.1	72.3
85.	Asiatic Petroleum Corp.	33.0	0.1	72.4
86.	Allis-Chalmers Mfg. Co.	31.2	0.1	72.5
87.	Sundstrand Corp.	31.2	0.1	72.6
88.	Control Data Corp.	30.1	0.1	72.7
89.	Hazeltine Corp.	29.6	0.1	72.8
90.	Dynalectron Corp.	29.6	0.1	72.9
91.	Defoe Shipbuilding Co.	29.3	0.1	73.0
92.	Flying Tiger Line, Inc.	29.0	0.1	73.1
93.	Loral Electronics Corp.	28.6	0.1	73.2
94.	Texas Instruments, Inc.	28.6	0.1	73.3
95.	Air Products & Chemicals, Inc.	27.7	0.1	73.4
96.	Atkinson (Guy F.) Co.	27.3	0.1	73.5
97.	Carrier Corp.	26.9	0.1	73.6
98.	Clark Equipment Co.	26.9	0.1	73.7
99.	U. S. Lines Co.	26.7	0.1	73.8
100.	Phillips Petroleum Co.	26.5	0.1	73.9

ENGINEERING TEST LABS

- FLUIDS
- STRUCTURAL
- ELECTRICAL / ELECTRONIC
- STANDARDS

GD/FW
AEROSPACE
SOUTHWEST
PIONEER

- STABILITY, GUIDANCE AND CONTROL
- RADAR, RFI, INFRARED, AND OPTICS
- OPERATIONS RESEARCH
- NUCLEAR SCIENCES
- STRUCTURAL SCIENCES
- FLIGHT SCIENCES
- STRUCTURAL AND MECHANICAL DESIGN

GD/FW is currently engaged in many outstanding projects involving atmospheric and space vehicles and systems. Energetic, creative engineers and scientists are needed now, to help solve the intriguing problems involved in our many ambitious programs. ■ FORT WORTH is a modern, clean, interesting city. The area has the second largest concentration of aerospace industry in the nation. High quality homes—urban, suburban, and rural—are available close to General Dynamics at surprisingly low prices. ■ Driving is easy; traffic density is low. Freeways lead directly to the ample parking facilities of General Dynamics/Fort Worth, and nearly all residential areas are less than 20 minutes away. There is no fog, no smog, no smoke and no soot. ■ More than 100 parks cover a total of about 5,000 acres. There is a fine zoo, a famed botanic garden, swimming pools, tennis courts, baseball diamonds, picnic facilities, horseback riding, Southwest Conference and NFL football, bowling, Casa Manana theater-in-the-round, sports car races . . . and the world's largest indoor rodeo—the Southwestern Exposition and Fat Stock Show. ■ Six large lakes are within minutes from downtown—three are in the city limits. ■ Fort Worth has one of the nation's better school systems. For higher education, there is Texas Christian University, Arlington State College, Southern Methodist University, and several other colleges and universities in the area. ■ To take advantage of the opportunities offered, write Mr. J. B. Ellis, Industrial Relations Administrator-Engineering, General Dynamics/Fort Worth, P. O. Box 748, Fort Worth, Texas, An equal opportunity employer.

GENERAL DYNAMICS | FORT WORTH

Rapid-Charge Space Battery Developed

by Michael Getler

NEW YORK—Application of closely controlled diodes to nickel-cadmium batteries for satellite use has yielded a new battery that developers say can be discharged to 70% of its capacity and fully recharged in orbit in about one hour.

Developed in a joint Air Force program with the Sonotone Corp., and P. R. Mallory & Co., Inc., the new technique is said to have reduced the previous charge rate of Sonotone's hermetically sealed nickel-cadmium batteries by 15 hours, with a corresponding increase in usable watt-hour capacity up to four times greater than earlier devices for fast charge, deep-discharge cycling.

Sonotone engineers also point out that since more of the nominal capacity of the battery will be available, the use of a smaller cell for the same cycle requirements will be possible.

- **Key diode**—Heart of the new technique is a device known as a "stabister," a Mallory diode that exhibits a very tightly specified forward voltage breakover and a very low dynamic impedance. This is achieved, according to Sonotone, by careful control of the breakover characteristics of the p-n junction and the mechanical assembly methods.

The stabister, which is basically involved with the fast-charging capabilities of the battery, weighs only 10 grams and is attached to each battery cell without redesign of the battery, according to the firm.

Addition of the stabister will not increase the cost of the battery by more than 5%, says Sonotone, because of the unit's simplicity.

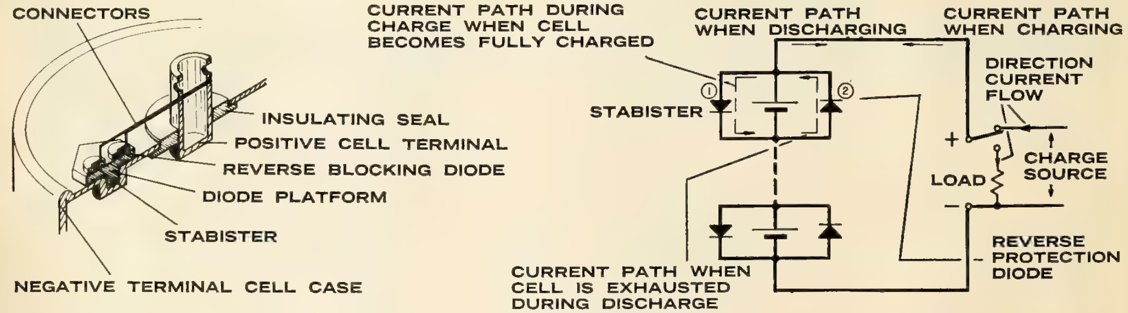
The stabister diode on each cell prevents current from flowing into that cell, while the battery is being charged, after the cell terminal voltage has reached a prescribed level. By doing so, Sonotone reports, gas evolvement is eliminated, with a consequent reduction in internal cell pressure and temperature rise.

- **Another diode**—The second diode involved with the new battery is a low-voltage germanium blocking-type used in connection with the safe deep-discharging of the cells. In effect, it prevents any nickel-cadmium cell from going into deep reverse charge.

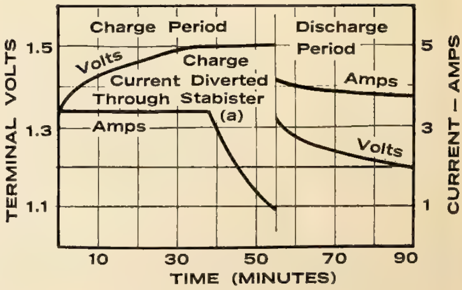
This diode, which involved development of a device with what Sonotone calls "the lowest possible forward voltage breakover," is used across the cell with the polarity arranged so that the diode is biased off when the cell terminal voltage is normal.

The diode proceeds to conduct current around the cell when the voltage of the cell goes to —0.3 volts.

At the AF Aero Propulsion Laboratories at Wright-Patterson AFB, Sonotone reports its commercial "D" size cells, using the Mallory stabisters, have been cycled 2,200 times under 75% depth of discharge conditions. The AF, as a result, has reportedly given a "go ahead" to both firms for additional testing aimed at providing stability over a wider temperature range. ■


CONNECTORS
INSULATING SEAL
POSITIVE CELL TERMINAL
REVERSE BLOCKING DIODE
DIODE PLATFORM
STABISTER
NEGATIVE TERMINAL CELL CASE
CURRENT PATH DURING CHARGE WHEN CELL BECOMES FULLY CHARGED
CURRENT PATH WHEN DISCHARGING
CURRENT PATH WHEN CHARGING
STABISTER
①
②
DIRECTION CURRENT FLOW
+
−
CHARGE SOURCE
LOAD
REVERSE PROTECTION DIODE
CURRENT PATH WHEN CELL IS EXHAUSTED DURING DISCHARGE

TOP LEFT: Cross section of Sonotone nickel-cadmium space cell with stabister system. TOP RIGHT: Stabister operating circuit, showing current-diverting protection paths provided by dual diode circuit, for the individual nickel-cadmium cells. Paths allow series-connected cells to be rapidly charged and safely discharged under all load conditions. BOTTOM RIGHT: Typical duty cycle for a low altitude space orbit showing the stabister diode (no. 2, top right figure) diverting excess charge current from nickel-cadmium cell at (a) on curve.



Astronauts 'Flying' IBM Simulators

Gemini mockup, five-man spacecraft unit will aid in determining features needed in future on-board guidance systems

by Charles D. LaFond

C. D. BABB, right, IBM's Gemini guidance system project manager, briefs Astronaut James McDivitt in Gemini simulator.

OWEGO, N.Y.—Two manned spacecraft simulators being developed here by IBM's Federal Systems Div. will provide definitive requirements for future on-board guidance systems.

The *Gemini* simulator was checked out recently by four NASA astronauts—Neil Armstrong, Virgil Grissom, James McDivitt and Edward White. A five-man simulator is also under development.

The *Gemini* unit is part of the division's guidance system subcontract with McDonnell Aircraft Corp., prime contractor for the maneuverable *Gemini* spacecraft.

The Space Guidance Center facility, which includes a *Gemini* mockup and a hybrid analog/digital computer complex for programming and performance processing, permits accurate modeling of the vehicle guidance computer being developed at the Center. It will be used later to integrate the inertial guidance system being developed for IBM by Minneapolis-Honeywell.

In the recent tests, each astronaut "flew" a number of eight-minute runs, manually guiding the simulated spacecraft from the point of Earth re-entry down to 50,000 ft., the range of drogue-chute deployment.

In actual operation through re-entry, aerodynamic lift will be generated by the *Gemini* spacecraft as it passes into the heavier atmosphere. Lift must be controlled carefully at this time to prevent the spacecraft from overshooting, undershooting or veering to either side of the planned touchdown point.

Lift will be controlled automatically by rolling the spacecraft about its longitudinal axis with reaction jets, with the on-board digital computer calculating the errors and issuing command signals to the control jets. A manual mode is also provided. In the latter, the pilots will make attitude corrections with a control stick based on computer outputs displayed on the cockpit control panel.

• **Test results**—In the recent tests, the astronauts controlled the spacecraft in the manual and rate command mode. An IBM 7090 computer, programmed to perform as a *Gemini* on-board guidance computer, was fed data simulating the aerodynamic forces acting on the spacecraft, the touchdown point location, gimbal angle and accelerometer readings such as might come from the Honeywell inertial-measuring unit, and other typical flight data.

As each pilot worked his control stick in response to the instrument indications, stick movements were measured by the computer. The changes in vehicle spatial orientation were computed and fed back to the cockpit instruments in real time.

Pilot response was recorded on three sets of plotters driven by the 7090 computer. Two were X-Y types: one compared downrange error with cross-range error and the other compared spacecraft attitude with downrange error. The third plotter provided eight data traces depicting instrument readouts, actual stick movements, spacecraft roll rate as a result of stick movements, and range errors.

Within two to three minutes after each simulated flight, the latter flight record provided a means for examining pilot performance, including spacecraft control, touchdown target accuracy, total reaction jet usage with respect to time and total fuel consumption.

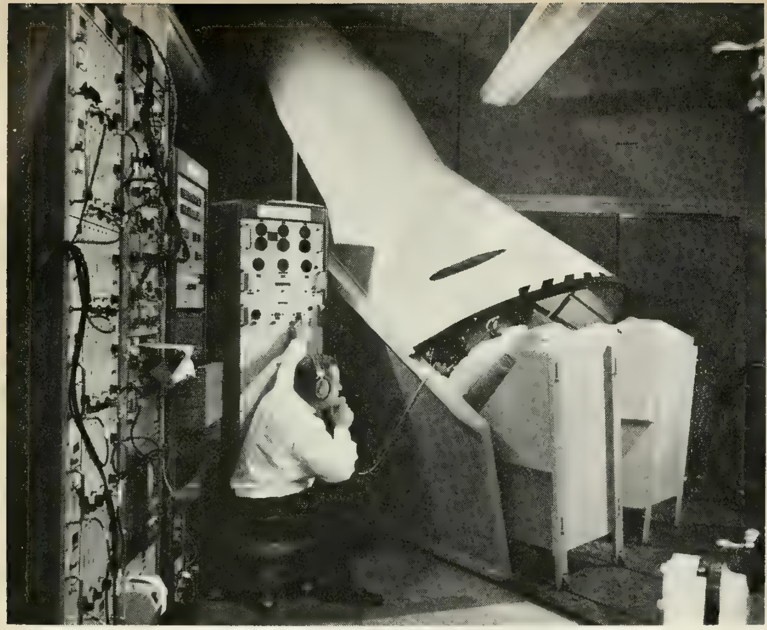
• **Hybrid simulation ADP**—In the interest of flexibility and economy, IBM engineers have used the advantages of both analog and digital computation in the design of the *Gemini* simulator for real-time operation.

The problem inherent in studying any complex control system, they pointed out, is that the simulation problem usually exceeds the capacity of the analog computer (e.g., the number of nonlinear elements or function generators becomes intolerable or impractical). Use of an accompanying digital computer permits relief of the total load by handling many of the non-linear computations and the control logic.

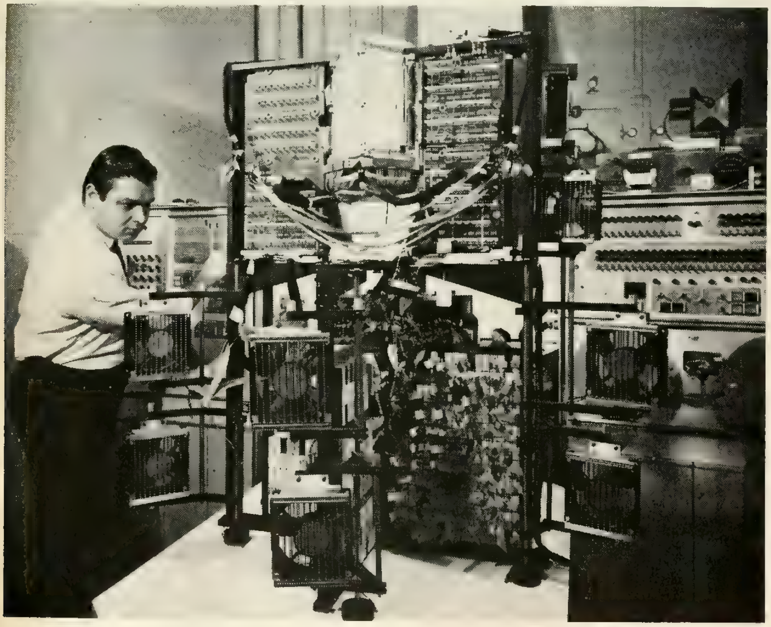
Conversely, the higher frequency dynamics of the control simulation problem demands small time increments during integrations in digital computations. The result is often a digital-computer time to real-time ratio of as much as 50 to 1. The use of an analog computer for such solutions greatly reduces computer time required.

Major elements of the Center's computer complex used in spacecraft simulations include the IBM 7090 data-processing system, an Electronics Associates, Inc., analog computer, a specialized digital differential analyzer, and a data controller with a real-time control unit.

To obtain greater efficiency from the high-speed and high-capacity 7090, a multiprogramming system was developed to permit concurrent solution of other scientific problems. When the hybrid requires computation, an inter-



EIGHT-MINUTE flights were performed several times each by four astronauts recently in the first checkout of IBM's new Gemini guidance simulator system.



OPENED GEMINI guidance computer is introduced into the Gemini simulator processing system. IBM will integrate the digital flight computer with a Minneapolis-Honeywell inertial guidance system.

rupt is signaled and control passes to a direct data program, which is that employed for the hybrid simulation problem.

The trend, until recently, in space vehicle control has been toward fully automatic systems, R. E. Eckstrom, manager of the simulation laboratory, said. With the current emphasis on manned flight, however, the attributes of a thinking being will be employed, thus giving the pilot his traditional responsibilities of vehicle control. The problem is to determine what tasks he is best able to perform in the control loop and which should be left to automatic processes.

It is hoped the new simulator will provide many of the answers to questions involving displays, instruments and controls.

- **Five-man simulator**—Also under development here at the Space Guidance Center is a highly advanced five-man spacecraft simulator.

A very high degree of realism will be achieved with the larger system, IBM scientists disclosed, in that the vehicle mockup will be installed within a theater-like enclosure. All the sights and sounds associated with launch, Earth orbits, rendezvous, mid-course maneuver, and lunar or planetary landings will be reproduced, providing an external environment directly related to the cockpit displays and control effects.

Several closed-circuit TV cameras providing different presentations will heighten the illusion of space flight.

Flight sounds, the company disclosed, will be superimposed on the UHF, HF and intercom channels used by the astronauts for voice communications. Appropriate engine noise level, re-entry and other recognizable sounds will be produced by computer direction, providing auditory cues. Also, warning sounds will be introduced to test astronaut reaction to simulated emergencies.

Throughout the new system, operator response will be measured to an accuracy of 0.001 sec., IBM claimed.

Control movements and switch actuation will produce changes in instrument readings, display presentations, and theater projections. Operator response will be fully recorded. The time an astronaut needs to manipulate the appropriate switches in the event of an emergency can be measured, as well as his reaction time in analyzing scope presentations and maneuvering the vehicles correctly.

Various combinations of switch locations, instrument configurations and scales, and alternate modes of operation can thus be tried out in the simulator to determine the best final setup for actual flight. The advanced five-man spacecraft has been completed and is now undergoing a rigorous checkout.

Meanwhile, simulation studies have already been prepared outlining the use of the new simulator for orbital rendezvous missions and for all phases of a manned Moon flight: Earth launch and orbit, mid-course flight, lunar orbit and descent, lunar launch and Earth reentry.

A study has also been prepared by IBM which examines some of the problems involved in simulating a Mars reconnaissance flight. Simulation specialists at Owego estimate that the Systems Simulation Laboratory will be capable of making its first "flight" to Mars early in 1964. ■

T/M Chain Collects Real-Time Data

by Rex Pay

TYPICAL DATA acquisition unit in chain. Antenna tower supports a standard communications antenna, four UHF antennas and two microwave dishes.

EDWARDS AFB, CALIF.—A chain of unmanned telemetry collection and relay stations now provides the Air Force Flight Test Center here with real-time data from aerospace vehicles flying over a 1,000-mile test range extending from Great Salt Lake to Edwards.

Currently the range is being used for *X-15* testing. Later it will be used for RS-70 tests and, possibly, hypersonic research vehicle tests (M/R, Nov. 25, p. 211).

Cost of the new range telemetry system in its present configuration has amounted to about $3.6 million. Main contractor for the system is the Military Electronics division of Motorola, Inc.

The new system can provide instrumentation support to four simultaneous independent flight-test missions. Projected requirements for the system include radar and optical-tracker target acquisition and composite operation support, real-time computer access capability, television relay, as well as the expected inter-range (PMR and NOTS) operations.

Two different types of transportable units make up the new telemetry system. The first is a Data Acquisition Unit (DAU) that receives telemetry from test vehicles and retransmits it back toward Edwards. Second is a Microwave Relay Unit (MRU) that acts as a repeater station between DAUs.

By this means, data (voice, biomedical, and engineering) is telemetered continuously to the test center as the vehicle passes over the 1,000-mi. range. Control of the entire system is maintained from Range Terminus Building 5780 at Edwards.

DAUs are located at Shoshone, Worthington and Ely, Nev., and at Worthington, Utah. Seven MRUs are interspersed throughout this chain.

The actual range therefore extends a minimum of 150 miles past Wendover, and has a width of about 300 miles.

Branches run into the main trunk to carry search radar data from the Angel Peak and Boron Air Defense Command sites. Flight test data are also injected into the system at manned sites at Beatty and Ely, Nev.

All information is routed through the Range Terminus to the Test Control Facility, the Master Radar Facility and the NASA *X-15* Control Room. Incoming data to the terminus are distributed to the range users via on-base RF data transmission links.

Because data can be received at more than one DAU at the same time, the capability of selecting the best data for transmission is built into each unit. At the DAU the signal-to-noise ratios of the two corresponding channels (that received locally and that received from a neighboring DAU via the microwave link) are compared and the best signal is selected for re-transmission toward Edwards.

The system is not designed around a certain data format or method of modulation. It handles FM/FM and PCM telemetry for the Air Force and PDM telemetry for NASA.

All individual range units outside of Edwards are entirely unattended. Full control of turn-on, channel selection, transceiver tuning, and turn-off is exercised from Building 5780. Secondary control of certain items can be carried out from two other buildings.

The control system is based on a tone-coding method for on-off and position-switching functions. Monitoring of these functions is accomplished by a similar code, except for analog information such as fuel level, which is used to modulate voltage-controlled oscillators.

Portability of units has been emphasized. If the need arose, the complete system could be relocated into a different configuration.

The general real-time simultaneous-data capabilities of the system are four standard VHF wideband telemetry channels; one search-radar video, or one 600-kilobit PCM channel; one 800-kilobit PCM channel; five duplex digital-radar channels; four 19-channel-capability air-ground UHF voice communication channels; one-, 100-, and 1,000-pps time-of-day coded timing; and range operation and maintenance voice channels, as required.

For the most part the new AFFTC range data system incorporates existing off-the-shelf equipment. No basic data communication equipment other than interface or compatibility hardware, was fabricated for the system. Major effort was expended in the area of monitoring and control equipment to exercise the system in real time.

The basic microwave system is a commercial design adapted to Government frequencies. All voice, low-rate digital-tracking data, control and timing channels are carried over commercial multiplex equipment. Remote turn-on is achieved with transistorized taxicab two-way radios, with special interface equipment.

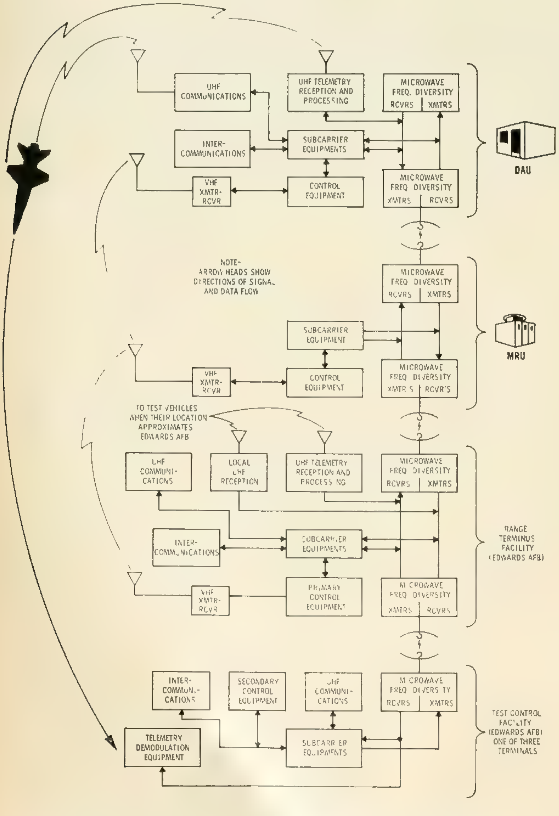
The voltage-controlled oscillators and phaselock loop converters and discriminators of the wide-band channels are transposed designs of systems proven in missile guidance. Telemetry receivers, UHF communications transceivers, multicouplers, and preamplifiers are all modified commercial products.

The Data Acquisition Unit is a self-contained electronic package housed in a helicopter drop-shelter. From the unit, two frequency-diversity channels are propagated to the next out-range site and another two channels to the next in-range (toward Edwards) site, to provide reliability through redundancy.

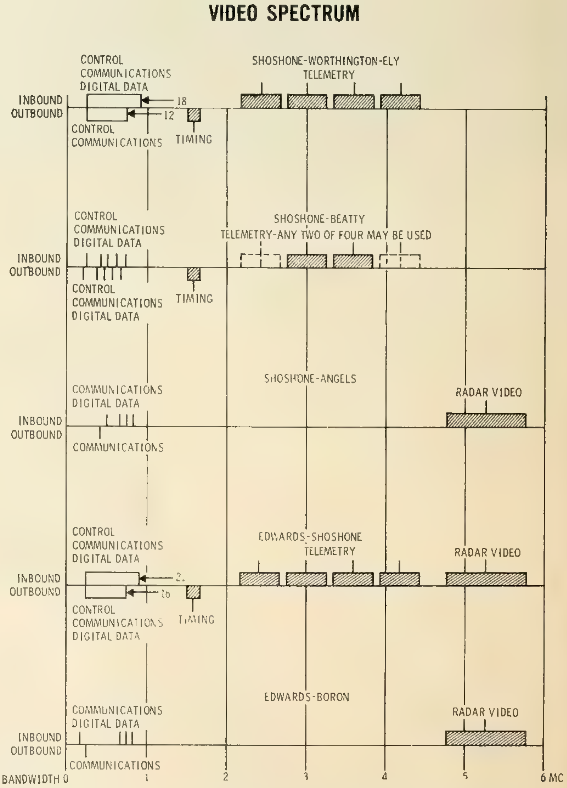
Antennas at a DAU site are mounted on a single tower and include a standard AS505 communications antenna used as an omni-directional telemetry antenna, four AT197 UHF A/G radio communications antennas, and two microwave dishes. Two diesel generators provide primary power and backup at each site.

Each microwave relay unit contains only two-way frequency-diversity microwave receivers and transmitters, and remote control equipment. The unit is constructed in three sections, any one of which can be transported in a half-ton pickup truck.

Tests on the system have yielded data signals that on demodulation at Edwards have consistently run from 35 to 45 db above noise, regardless of where they were injected into the system. The basic accuracy of the data transmission is greater than that of the measuring equipment. ■


UHF COMMUNICATIONS
UHF TELEMETRY RECEPTION AND PROCESSING
MICROWAVE FREQ. DIVERSITY RCVRS XMTRS
INTER-COMMUNICATIONS
SUBCARRIER EQUIPMENTS
VHF XMTR-RCVR
CONTROL EQUIPMENT
MICROWAVE FREQ DIVERSITY XMTRS RCVRS
DAU
NOTE- ARROW HEADS SHOW DIRECTIONS OF SIGNAL AND DATA FLOW
MICROWAVE FREQ DIVERSITY RCVRS XMTRS
SUBCARRIER EQUIPMENT
VHF XMTR-RCVR
CONTROL EQUIPMENT
MICROWAVE FREQ DIVERSITY XMTR'S RCVR'S
MRU
TO TEST VEHICLES WHEN THEIR LOCATION APPROXIMATES EDWARDS AFB
UHF COMMUNI-CATIONS
LOCAL UHF RECEPTION
UHF TELEMETRY RECEPTION AND PROCESSING
MICROWAVE FREQ DIVERSITY RCVRS XMTRS
INTER-COMMUNICATIONS
SUBCARRIER EQUIPMENTS
VHF XMTR-RCVR
PRIMARY CONTROL EQUIPMENT
MICROWAVE FREQ DIVERSITY XMTRS RCVRS
RANGE TERMINUS FACILITY (EDWARDS AFB)
INTER-COMMUNI-CATIONS
SECONDARY CONTROL EQUIPMENT
UHF COMMUNI-CATIONS
MICROWAVE FREQ DIVERSITY RCVRS XMTRS
TELEMETRY DEMODULATION EQUIPMENT
SUBCARRIER EQUIPMENTS
TEST CONTROL FACILITY (EDWARDS AFB) ONE OF THREE TERMINALS

COMMUNICATIONS FUNCTIONS carried out by units of FTC data acquisition and transmission system.



FREQUENCY DISTRIBUTION in Edwards-Ely section of FTC data acquisition and transmission system.

Space Frame Radome

A 55-ft.-dia. metal space frame radome, offering a maximum transmission loss of 0.5 db at L-through X-band frequencies, is available from Electronic Space Structures Corp.

The Model M55-70 is constructed of extruded aluminum frames with fiberglass reinforcing plastic membranes. The structure is designed to withstand wind loads of 150 mph and ice and snow loads to 70 lbs./ft.^{2} Solar energy rejection is 90 to 95%.

Boresight error is less than 0.1 milliradian; maximum noise temperature contribution is 10°K.

Circle No. 225 on Subscriber Service Card

Low-Distortion Amplifier

MB Electronics has available the Model T252 amplifier, designed for sine and random testing with vibration exciters. The device can also be employed in sonar and other high-power acoustical tests.

When used with the MB Model EL-250 exciter, the amplifier will produce a 3,000-lb. vector force at 100 g over a range of 5 to 3,000 cps. With the Model C20 exciter, it produces a 1,750-lb. vector force at 100 g, 5 to 3,000 cps.

Distortion is less than 3% at 5 to 10 cps, 1.5% from 10 to 2,000 cps, and 3% at 2,000 to 6,000 cps. The unit produces a 5-kva output to drive the exciters at frequencies of 25 to 6,000 cps.

Circle No. 226 on Subscriber Service Card

Delay Line Synthesizer

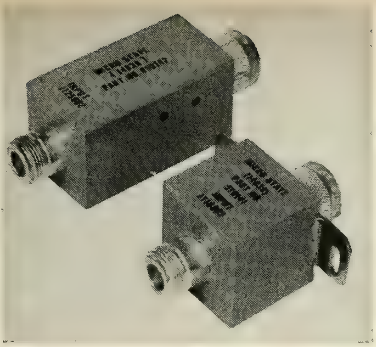
The Model 73-11 Delay Line Synthesizer, which incorporates a variable filter ahead of the delay line, is being marketed by Allen Avionics, Inc.

The unit has a time delay from 0.025 to 11.075 μsec in 0.025-μsec increments. Rise time is 0.055 microsecond at 2-μsec delay; 0.13 μsec at 6-μsec delay, 0.215 μsec at maximum. delay. Accuracy of time delay is 0.5%; accuracy of rise time control is 5%. Impedance is 50 or 73 ohm, input or output-switch controlled.

Circle No. 227 on Subscriber Service Card

Octave Band Limiters

Micro State Electronics Corp. has expanded its solid-state passive limiter line to cover the octave bandwidth. The models L-141, L-142 and L-1000 handle nominal average power of 20 watts and are supplied with type N connectors.



L-141 has a frequency range of 250 to 500 mc, 1.5 maximum VSWR, 0.5 db insertion loss, and 30 db minimum limiting level.

L-142 has a 500 to 1,000-mc frequency range, 1.25 input VSWR, 0.75-db insertion loss, and 25-db minimum limiting level.

L-1000 has a 1,000 to 2,000-mc frequency range, 1.3 maximum VSWR, 0.5-db insertion loss and 22-db minimum limiting level.

Circle No. 228 on Subscriber Service Card

Signal Conditioner

Scionics Corp. is marketing the Model MSC-136 solid-state signal conditioner that operates with resistive temperature sensors to provide a 5-v dc full scale output.

The unit provides output for temperature differentials as low as 2°F and withstands 35 g's vibration and 100 g's shock. Accuracy exceeds 2% of full scale temperature. Input resistance is 200 to 500 ohms and non linearity and hysteresis are better than ±0.1%. Operating temperatures are from −65° to 200°F.

Circle No. 229 on Subscriber Service Card

Electromechanical Chopper

Airpax Electronics, Inc., has developed the Model 83 electromechanical chopper with noise of less than 25 mv into a load impedance of one megohm.

The device has DPDT BBM contact switching action, which handles signal levels up to 10v dc, 1 milliampere. The unit will withstand vibrations of 10 g's at 55 to 2,000 cps and 30 g's shock. Volume is 0.51 cu. in.

Circle No. 230 on Subscriber Service Card

Varactor Multipliers

Solid State Products Div. of Varian Associates has available a series of varactor multipliers with output power from 15 watts at VHF to 10 milliwatts

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Circle No. 3 on Subscriber Service Card

at 35 gc. Operating efficiencies range from 35 to 80%, depending on application and order of multiplication.

Output power is 250 mw CW. Output frequency is 9.6 gc. The units have a bandwidth of 2% and 38% efficiency. Power stability is 1 db.

Circle No. 231 on Subscriber Service Card

Programming Board

Sealectro Corp. has developed a three-deck Sealectroboard, featuring cordless programming and a third contact deck in the vertical plane.

Any combination of decks can be electrically connected by inserting shorting or skip pins at approximate X-Y points. The three-deck unit provides a 3-pole switching function at each X-Y point. All contacts are goldplated to maintain maximum electrical efficiency.

Circle No. 232 on Subscriber Service Card

Dual-Cavity Laser

Ratheon Co.'s Laser Advanced Development Center has available a dual-cavity laser that delivers up to 250 joules.

The Model LHM-6 employs a ruby laser rod and has an input of 20,000 J. Both ends of the laser crystal are open and accessible, thus allowing modifications, such as "Q-spoiling," to be made without changes to the laser head.

The device has a pulse width of 3 milliseconds and employs 10,000-J xenon lamps as flashtubes. Output wavelength is 6,943 Å at room temperature and 6,934 Å at liquid nitrogen temperatures.

Circle No. 233 on Subscriber Service Card

C-Band Limiter

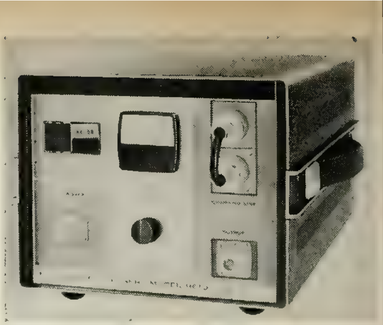
Micro State Electronics Corp. is marketing the Model L-5603 C-band limiter, designed for monopulse radar systems.

The unit has a frequency range of 5,400 to 5,900 mc. Input VSWR is less than 1.2 and maximum insertion loss is less than 0.75 db. The limiting level across the frequency range is 20 db nominal and will handle average power of 10 to 30 watts nominal.

Circle No. 234 on Subscriber Service Card

Nanosecond Pulse Generator

Systems Div. of Huggins Laboratories, Inc., has available a high-level nanosecond pulse generator, providing flashes of light with electrical pulses generated at 51 ohms impedance level.



The Model 961-D has a light pulse output yielding more than 10,000 photoelectrons per pulse from an S11 cathode subtending 0.005 steradian at the source. Rise time is less than ½ nanosecond; amplitude jitter does not exceed 4% on short term basis.

Electrical pulse is positive with a variable amplitude from 0 to 2,000v. Rise and fall time is less than ½ nanosecond.

Circle No. 235 on Subscriber Service Card

High-Voltage Power Supply

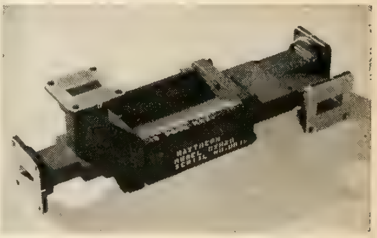
Electro-Glass Laboratories, Inc., is marketing the Model 110 High Voltage Power Supply with double section choke input filter and full wave rectification.

The device features an output of 0 to 5,000v dc at 500 ma. It has reversible polarity output and continuously variable output with 1% venier. Ripple at full load is 2%. Output impedance is 40 ohms. Power requirement is 220v ac, 50-60 cps.

Circle No. 236 on Subscriber Service Card

Phase Shift Circulator

A differential phase-shift circulator handling peak powers up to 300 kw and average powers up to 300 watts over a frequency band of 8.2 to 10 kilomegacycles has been introduced by Raytheon Co.'s Special Microwave Devices Operation.

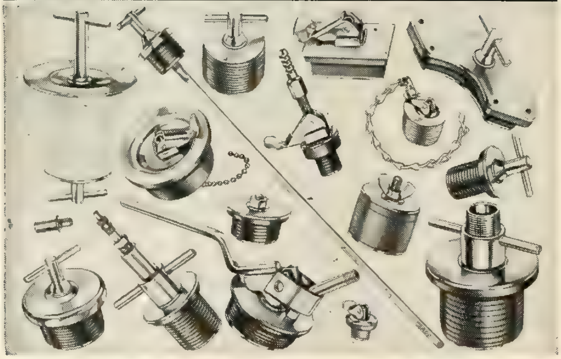


The Model CXH20 has an isolation of 20 db and insertion loss of 0.3 db. VSWR is 1.20. Isolation exceeding 25 db is obtainable over a frequency band 1 gc wide inside the operating range.

Circle No. 237 on Subscriber Service Card

MOELLER HIGH-SPEED ADJUSTABLE CLOSURES

Fit any size or shape opening



The patented adjustable action of Moeller's Snap-Tite® and Turn-Tite® cam and lever type action closures makes it possible to design a low-cost stopper in virtually any size or shape.

Made of cold-rolled or stainless steel and high-grade neoprene, or other specified materials, these new closures offer many opportunities to cut costs in product design, labor, time and assembly. For additional information, write . . .

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Greenville, Mississippi

Circle No. 4 on Subscriber Service Card

Electronics Oven

Electronics Div. of Bulova Watch Co. is marketing an oven designed especially for controlling crystals, packaged circuits, transistors and other temperature-sensitive devices.

The Model AM 250-11 has a temperature stability of 0.25° C in a fixed ambient and will maintain a stability of 2.5° C through an ambient of —55° to 10° C below the nominal setting of the oven. The cylindrical unit has an internal volume of 4 cu. in. and a range of 25° to 100° C. Voltage range is from 6 to 120v dc or ac, 60 to 400 cps.

Circle No. 238 on Subscriber Service Card

C-Band Klystron

Fairchild Semiconductor Div. of Fairchild Camera and Instrument Corp. is marketing a solid-state C-band microwave source with single-screw tuning.

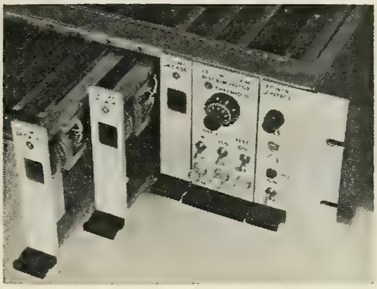
The Model MS 100 is mechanically tunable through the 5.4 to 5.9-gc range and voltage-tunable over a 1% bandwidth. Minimum output power is 10 mw with spurious noise 60 db down over the rated frequency and more than 50 db down outside the range. Modulation sensitivity is approximately 20 Mc per volt; long-term frequency stabilization exceeds four parts in 10^3 over a temperature range of —55° to 100°C.

Circle No. 239 on Subscriber Service Card

Instrumentation Modules

American Missile Products Co., Inc., is marketing the MC series of functional instrumentation modules for use in analog and digital systems.

The units plug into a rack mounting module cage, which has integral power supplies of 15v regulated, —15v regulated and 225v unregulated. The module cage will contain up to 16 one-in.-wide modules. Scalers have a nixie tube display on the front panel and an 8, 4, 2, 1 binary coded decimal readout is available on the rear connector.



Circle No. 240 on Subscriber Service Card

Laser Power Meter

A self-contained power meter for measuring output of continuous lasers and other light sources has been introduced by Optics Technology, Inc.

The Model 610 consists of a broadband detector, a meter calibrated in milliwatts and six dynamic ranges. Input aperture is one inch.

The device measures signal levels between 0.03 and 1,000 milliwatts. An oscilloscope or strip chart recorder can be attached. The unit has a spectral range from 4,000 to 11,000 Angstroms, and is calibrated at 6,328 Angstroms to ±2% against the OTI standard.

Circle No. 241 on Subscriber Service Card

PCM T/M Ground Station

A stored-program PCM telemetry ground station which supplies data and identification information directly to an on-line digital computer or computer complex has been announced by Monitor Systems, Inc.

The Model 1110 contains no patchboards; programming is provided by a magnetic-core memory with capacity for storing up to four telemetry formats simultaneously. Formats may be introduced by paper tape, a keyboard or a computer.

The system provides instantaneous selection of one of nine pre-synchronized telemetry links. Data words may be up to 64 bits and may be subdivided into syllables.

Circle No. 242 on Subscriber Service Card

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Grumman's steady advance in these areas has been sparked by the engineers and scientists who spearhead the company. Our design, development and study activities include vehicles and systems for programs ranging from submarine searching to space stations.

We cordially invite those engineers and scientists with kindred experience, who are determined to make '64 a year of achievement, to immediately investigate these specific opportunities.

Senior Heat Transfer Engineers—BS or MS with minimum of 5 years training and experience in structural heat transfer analysis is required. Will develop IBM programs and other analytical tools as needed to handle complicated configurations and end condition for space vehicle structures and propulsion systems. Must be capable of determining temperature distributions and recommended heat transfer configurations for initial structural designs and the detailed analyses, and test verification work to complete the design.

Reliability Test-Propulsion—BS in ME or equivalent with 5 years experience in propulsion system testing or design. Knowledge of rocket engines, preferably hypergolic type, required. Positions available for reliability planning and monitoring of propulsion test programs at Bethpage and at White Sands Missile Range. Background in statistical analysis techniques desirable.

Reliability Engineers—BS in EE, ME, AE and experience on aerospace systems, to engage in system and sub-system reliability control activities including one or more of the following: apportionment, prediction, configuration (trade-off) studies, failure mode and failure effect analyses, electronic circuit analyses, maintainability analyses, environmental analyses, implementation of reliability programs, design reviews, trouble data collection and analyses and vendor control. Special experience areas include: Propulsion, Environmental Control, Stabilization, Guidance & Control.

Space Power and Propulsion Systems Design Engineers—BS in Engineering with experience in design of liquid rocket motors, and/or space power supply (including nuclear) and associated systems. Duties include conception and design of storable and cryogenic bi-propellant rockets systems and space power systems.

Crew And Equipment Integration Design Engineers—BS in AE or ME with 3 to 5 years experience in crew station design and electronic equipment installation design layout. Knowledge of man-machine display and control layout and arrangements with analytical approach. Experience in high density equipment installations to meet rigorous vibration, thermal, structural and assessability requirements. Close association with spacecraft and aircraft makes pilot experience very desirable, but not mandatory.

Space Systems Engineers—BS or advanced degree with experience in the analysis of integration of overall systems for orbital and lunar exploration, reconnaissance or surveillance and space weapons applications. Applicants should possess working knowledge of the various components or subsystems of space systems such as communication, stabilization, guidance, digital and analog control, and environmental control systems, and have a good background in space mechanics. Positions encompass conceptual work in defining systems to match requirements, analysis and synthesis of these systems, simulation and final verification.

Systems Simulation Engineers—BS or advanced degree with experience in the simulation of large scale systems in the fields of space missions and satellites, airborne early warning, surface and airborne anti submarine, airborne attack and reconnaissance. The applicants should possess a strong mathematical background as well as intimate knowledge of analog, digital, and hybrid computers, their capabilities and limitations, real time simulation, integration of the human in the simulation loop, and display requirements. Positions entail the determination of simulation requirements, detailed simulation planning, scheduling, mathematical formulations, mechanizations, and analysis of results.

To arrange an immediate interview, SEND RESUME to Mr. P. M. Van Putten, Manager Engineering Employment, Dept. GR-86.

Grumman

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Circle No. 14 on Subscriber Service Card

Mergers and Acquisitions

Stockholders of the Garrett Corp. have agreed to a merger of the company with Signal Oil and Gas Co. Under terms of the merger, Garrett stockholders are to receive one share of a new convertible preferred stock to be issued by Signal for each share of Garrett. It will have a fixed dividend rate of $2.40 per share, compared with the traditional $2.00 rate on Garrett common. . . . *Control Data Corp., Minneapolis, has agreed to acquire the business and principal assets of Rabinow Engineering Co., Washington, D.C., subject to Rabinow stockholder approval. Rabinow is a research, development and production organization and has done work in electronic document reading.*

International

Baird-Atomic, Inc., Cambridge, Mass., has signed an agreement to produce and market in North America the Automatic Fluorescent X-ray Spectrometer Type XZ 1030 developed by Elliott Quality Automation Ltd., London. . . . *The Marquardt Corp., Van Nuys, Calif., and Bristol Siddeley Engines Limited of Great Britian have signed an agreement to interchange information relating to advance propulsion systems for supersonic and hypersonic flight. Initial collaboration will be limited to an exchange of information concerning supersonic and hypersonic ramjet engines, sub-systems and components.*

Facilities

Wyle Laboratories Test Div., Huntsville, Ala., facility has placed in operation a vibration system expressly for testing large structural parts of *Saturn* rockets. The system, largest of its kind ever built, is capable of producing 200,000 force pounds either horizontally or vertically. . . . *Lear Siegler's Romec Facility, Elyria, Ohio, has built a 2,800-sq.-ft. class 2 clean room for the assembly of servo valves, hydraulic rams and power packages.* . . . On Mark Couplings, a division of Purolator Products, Inc., is starting construction work on a new manufacturing and research facility in Rancho Conejo, light industry and research center in California Conejo Valley. The new plant will house West Coast headquarters for Purolator Products, and will supply manufacturing and test facilities for Purolator's aerospace filters, as well as housing On Mark's sales office, engineering department, machine shop and prototype shop, chemical laboratory and clean rooms. Research and development units are designed to allow incorporation of R&D work presently being done at Purolator headquarters in Rahway, New Jersey. The new building will give On Mark three times the working room of its present laboratories and will enable them to expand their activities in the area of contract testing. . . . *Missouri Research Laboratories, Inc., St. Louis, has established an office in Albuquerque, N.M., to serve as a base for expanded operations in the Albuquerque area. MRL makes automatic test and simulation equipment and has done considerable work in the past for the Sandia Corp.* . . . New York Testing Laboratories, Inc., Westbury, N.Y., has completed expansion to facilities bringing floor space to a total of 19,000 sq. ft. Major installations include a Ling sine-random 7,000-force-pound vibration system, a high impact shock tester, and walk-in chambers for temperature-altitude and temperature-humidity testing. . . . *Film Capacitors, Inc., has moved to expanded facilities in Passaic, N.J. The 20,000 sq. ft. of new production space more than doubles FC's former area in New York City. The new space will inable the firm to step up production output and to accelerate its research and development activities.* . . . Sulfrian Cryogenics, Inc., Hillside, N.J., has broken ground for a new 31,000-sq.-ft. office, manufacturing and research facility in Rahway, N.J. . . . *The Bethlehem Corp.'s Environmental Engineering Div. has installed a 3,500-cu.-ft. environmental testing facility with an altitude performance of over 200,000 ft. for Associated Testing Laboratories in Wayne, N.J. The facility will be used in testing missile, satellite and space vehicle components.* . . . *Atlantic Research Corp., Alexandria, Va., has opened a new $200,000 high-altitude research chamber. The 6-ft.-dia. x 25-ft.-long chamber will be used to study rockets and other gas generators at simulated altitudes of up to 50 mi.* . . . Advanced Scientific Instruments, Minneapolis, digital computer manufacturer and a division of Electro-Mechanical Research, Inc., has expanded its Southeast District sales office. Headquartered in Huntsville, Ala., the district office will be increased by the addition of a maintenance service center and applications support facility.

Company Representatives

Dynatech Corp., Cambridge, Mass., has appointed three new representatives to sell its engineering services and line of thermophysical properties measuring instruments. The W. J. Mauer Co. will cover the greater Chicago-Milwaukee area. Engineering Services Co., St. Louis, will cover Iowa, Nebraska, Missouri, Kansas and southern Illinois. Everitt V. Swenson will represent Dynatech at Wright Patterson AFB, Ohio. . . . *Liquidonics, Inc., Westbury, N.Y., has appointed four distributors to handle sales, service and parts for its line of hydraulic piston accumulators and related equipment. Air Equipment Company, Kansas City, Kansas, will cover Kansas and Missouri. H & R Sales and Engineering, St. Louis, will be responsible for the St. Louis area. California, Arizona, Nevada and Utah will be serviced by Mac Keller Air Controls Co., Los Angeles. Chapson Bros., Ltd., Honolulu, will represent Liquidonics in Hawaii.*

missiles and rockets

special report:

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It will include:

1 Introduction—growth trends, impact, state of the art.

2 Market Analysis
NASA Expenditures ☐ Military Expenditures
Industry Leaders & Major Contracts

3 Industry Analysis
Manufacturers, R & D Efforts ☐ Basic Materials, Suppliers, Growth Potential.

4 Technological Trends
Methods of component & circuit fabrication ☐ Manufacturing—automaticity, reproducibility, packaging, testing, yield, reliability ☐ Operating or environmental problems

5 Marketing Problems
Industry and government viewpoints.

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MICROELECTRONICS

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AWARDS

AIR FORCE

$7,600,000—**Fairchild Camera and Instrument Corp.**, Syosset, N.Y., for production of photographic equipment.

$6,400,000—**Ford Motor Co.'s Philco Corp.**, Palo Alto, Calif., for work on a satellite control network.

$3,500,000—**International Business Machines Corp., Federal Systems Div.**, Rockville, Md., for continued work on electronic data-processing equipment (supplemental contract).

$3,400,000—**General Electric Co.**, Philadelphia, for a *Minuteman* re-entry vehicle development study.

$2,400,000—**Burroughs Corp.'s Military Systems Div.**, Paoli, Pa., for work on North American Defense Command Combat Operations Center (supplemental contract).

$2,200,000—**General Electric Co.**, Syracuse, N.Y., for further work on *Titan I* and *II* guidance systems.

$2,000,000—**General Electric Co.**, Philadelphia, for *Titan II* missile work (supplemental contract).

$1,900,000—**Burroughs Corp.'s Defense and Space Group**, Paoli, Pa., for continued acquisition and integration of electronic hardware for the 425L system of AF Electronic Systems Div. at the North American Air Defense Command, Colorado Springs, Colo.

$1,800,000—**Aerojet-General Corp.**, Sacramento, Calif., for continued *Titan II* propulsion system development work related to the *Gemini* program.

$1,600,505—**Emerson Electric Manufacturing Co.'s Electronics and Space Div.**, St. Louis, for provision of a general-purpose automatic test equipment system for ultra-high-frequency communications sets and tactical air navigation systems (supplemental contract).

$1,600,000—**Aerojet-General Corp.**, Sacramento, Calif., for continued research and development activities on the *Titan III* missile engine.

$1,500,000—**General Dynamics Corp.**, San Diego, Calif., for continued production of launch-vehicle spare parts.

$1,400,000—**Electronic Communications, Inc.**, St. Petersburg, Fla., for communications equipment and services (several contracts).

$1,252,700—**Philco Corp.'s Aeronutronic Div.**, Newport Beach, Calif., for work on operational subsystems and services for *Atlas* and *Titan* missiles (supplemental contract).

$1,000,000—**Philco Corp.'s Aeronutronic Div.**, Newport Beach, Calif., for study and test of advanced means of penetrating enemy missile-defense systems (classified project).

$452,722—**Yardney Electric Corp.**, New York City, for production of missile batteries for use in *Falcon* GAR 1 and 2 air-to-air missiles.

$393,000—**Hoffman Electronics Corp.'s Military Products Div.**, Los Angeles, for production of TACAN coupling instruments.

$400,000—**Emerson Electric Mfg. Co.'s Electronics and Space Div.**, St. Louis, for repair and modification of 39 different types of Airborne Radio Navigation (ARN) instruments.

$347,500—**Martin Marietta Corp.'s Denver Div.**, Colo., for documentation to support provisioning actions for missiles, aerospace ground equipment and items, propellant transfer system and silo door activation system.

ARMY

$2,400,000—**Sylvania Electric Products**, Mountain View, Calif., for classified research and development activities.

$1,700,000—**Butler Mfg. Co.**, for production of containers to be used with *Pershing* missiles.

$1,700,000—**C&B Construction Co.**, for a component test facility at NASA's Marshall Space Flight Center.

$1,098,419—**Bendix Corp.'s Radio Div.**, Towson, Md., for production of low-speed digital circuit modules.

NAVY

$12,700,000—**Vitro Corp.**, Silver Spring, Md., for research and development related to the *Polaris* FBM weapons system.

$6,100,000—**Sperry Rand Corp.**, New York City for engineering efforts on a *Polaris* submarine navigation system.

$5,200,000—**Minneapolis-Honeywell Regulator Co.** St. Petersburg, Fla., for *Polaris A-3* missile gyroscopic equipment.

$4,900,000—**Lockheed Aircraft Corp.**, Sunnyvale Calif., for further production of *Polaris A-2* missiles.

$4,700,000—**General Motors Corp.**, Milwaukee for *Polaris A-3* guidance system gyroscopic equipment.

$3,700,000—**Westinghouse Electric Corp.**, Sunnyvale, Calif., for *Polaris* launching system programs for SSB(N).

$2,800,000—**Interstate Electronics Corp.**, Anaheim, Calif., for field engineering and support services in connection with fleet ballistic missile (FBM) weapon system program test instrumentation.

$2,600,000—**Collins Radio Co.**, Cedar Rapids, Iowa, for manufacture of ultra-high-frequency radio equipment.

$2,200,000—**Howard Research Corp.**, for engineering assistance in the design and development of *Polaris* missile system training equipment.

$2,000,000—**North American Aviation, Inc.**, El Segundo, Calif., for 16 inertial navigation system items to be installed aboard *Polaris* missile submarines.

$1,700,000—**Sperry Rand Corp.**, St. Paul, Minn., for computer development in an antisubmarine warfare program.

$1,600,000—**Thiokol Chemical Corp.**, Bristol, Pa., for *Bullpup* liquid-fueled air-to-ground missile engines.

$1,400,000—**Radio Corp. of America**, Burlington. Mass., for a classified electronics research and development effort.

$359,000—**Interstate Electronics Corp.**, Anaheim, Calif., for engineering research and development services in the development of test instrumentation in support of the *Polaris* program.

$120,000—**Servo Corp. of America.**, Hicksville, N.Y., for research in development of new infrared materials for use in missiles, rockets and other space vehicles.

NASA

$48,064,658—**Douglas Aircraft Co.'s Missile and Space Systems Div.**, Santa Monica, Calif., for development and production of the S-IVB stage, which will be used in the *Saturn IB* program (supplemental contract).

$4,750,000—**Bendix Corp.'s Pacific Div.**, North Hollywood, Calif., for complete installation of *Gemini-Agena* spacecraft information display console systems to be located at Global Tracking Network ground stations.

$2,221,083—**Chrysler Corp.**, Detroit, for engineering services supporting launch operations of the *Saturn* rocket (supplemental contract).

$2,200,000—**Electro-Mechanical Research Corp.**, Sarasota, Fla., for provision of five added PCM tracking station systems for the Global Tracking Network.

$1,100,000—**Lockheed Missiles & Space Co.**, Sunnyvale, Calif., for added funds and extension of definitization date of the current letter contract for the *Mariner C* program.

$138,119—**Douglas Aircraft Co.**, Santa Monica, for a study of high-strength extremely tough steel alloy for use in manufacturing large space vehicles.

$103,000—**Hallicrafters Co.**, Chicago, for provision of high-speed digital code translation data systems for the *Apollo* program.

$76,000—**Electronic Engineering Co. of California**, Santa Ana, for an EECO 751 scientific data processing system.

Electro-Mechanical Research, Inc., Sarasota, Fla., for conversion of a Baker-Schmidt astrographic telescope to a meteor telespectrograph (undisclosed amount).

INDUSTRY

$4,000,000—**General Dynamics/Electronics**, San Diego, Calif., from **Philco Corp.**, for computer display equipment for use in the Integrated Mission Control Center at Houston.

$149,000—**Fairchild Camera and Instrument Corp., Electronic Tube Div.'s Du Mont Laboratories**, Clifton, N.J., from **United Aircraft Corp.'s Hamilton Standard Div.**, for development of electron-beam welding techniques for the fabrication of electronic tubes.

$34,000—**Mobile Trailer Leasing, Inc.**, Denver, from the **Boeing Co.**, for transportable office structures.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Aerospace Medical Division
Attn: AMKRB
P. O. Box 35448
Brooks AFB, Tex.

Negotiations will be conducted with Southwest Research Institute, San Antonio, Tex., for research and reports on the study of radiation-induced free radicals in chemical and biological systems. For information only; no RFP available.

National Aeronautics and Space Administration
Manned Spacecraft Center
General Research Procurement
Houston, Tex.
Attn: D.C. Humes
WA 8-2811, Ext. 7305

Earth-orbital scene simulator display generator; delivery to NASA Manned Spacecraft Center, Houston 1, Tex. Unit—RFP MSC-64-933P. RFP due date 1-21-64.

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Va.

A contract for an analytical study to define an experimental program for evaluation and optimization of multielement large-aperture arrays is to be negotiated with Research Triangle Institute, Durham, N.C. For information only; RFP L-4062 not available.

U.S. Navy Department
Bureau of Ships
Washington 25, D.C.

Visual target classifier studies; visual tasks in spaceflight studies; sea-state determinations study and reports. RFP 362A-31225.3(S). Request for proposal will be issued to Dr. S. Q. Duntley, La Jolla, Calif. This is a continuation of studies presently in progress. Dr. Duntley has the unique background and experience essential to the conduction of these studies. It is suggested that small business firms and others interested in subcontracting opportunities make direct contact with Dr. Duntley.

Systems Engineering Group
Wright-Patterson AFB, Ohio

Negotiations are to be conducted with Engelhard Industries, Inc., Newark, N.J., for continuation of contract AF 33(657)-7849 for improved temperature control coatings from organometallic solutions. For information only; no RFP available. RFP C-6585-RB.

Headquarters
Space Systems Div.
AF Unit Post Office
Los Angeles, Calif. 90045

Six *Centaur* boosters. Contract is a follow-on award to General Dynamics Corp., Astronautics Div., 5001 Kearny Villa Road, San Diego, Calif. This firm is sole source for the above item. Small business firms and others interested in subcontracting opportunities should make direct contact with the above firm.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio

Negotiations will be conducted with Aerolab Development Co., 1900 Walker Avenue, Monrovia, Calif., for the inspection and repair as necessary and test loading of one set of Wasp first stage hardware. RFP STD-184. For information only; no RFP available.

Bureau of Naval Weapons
Washington 25, D.C.

Develop an effective process for producing fused silica radomes for *Tartar/Terrier* missiles. The Bureau of Naval Weapons contemplates entering into negotiations with General Dynamics/Pomona, Pomona, Calif. Solicitation will be made on the basis that this is the most acceptable firm familiar with fused-silica, slip-cast radome fabrication, to perform the work under the proposed contract. This notice is made for information purposes only. C/N 2108-64. BuWeps Synopsis No. 354-64.

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Ala.

Furnish all labor and materials to modify and convert existing YFNB barge to an S-II and S-IVB stage space vehicle transportation barge complete and ready for operation by NASA. The work shall be accomplished in accordance with general specs and guidance plans which will be furnished with the RFQ. A bidders' conference will be held on board the vessel, located at the U.S. Navy Reserve Fleet, San Diego, Calif., on Jan. 8. Attendance is considered mandatory for all potential proposers due to lack of definitive specs. Intent to propose and attend conference must be received by MSFC, NASA, by close of business Jan. 3. Phone: 205-539-2026, J. C. Thompson. The following firms are on the initial source list: Bethlehem Steel Co., San Francisco; Camubell Machine, Inc., San Diego, Calif.; Forster Shipbuilding Co., Terminal Isle, Calif.; Martinolich Ship Repair Co., Oakland, Calif.; National Steel and Shipbuilding, San Diego, Calif.; Todd Shipyards Corp., San Pedro, Calif., Pacific Dry Dock and Repair, Oakland, Calif., and Avondale Shipyards, New Orleans, La.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Ala.
Attn: R. T. Minard

Designs, fabrication, checkout and delivery of complete ultrasonic automatic scanning and recording systems capable of producing A 1-2-1 scale facsimile C-scan recording of the condition of a metal, for the scanning of the interior of materials and welds and facsimile recording of their characteristics. Delivery to Marshall Space Flight Center. RFQ DCN 2-4-17-006024. Reissued proposals due 1-27-64. All information available is contained in RFQ.

Systems Engineering Group
Wright Patterson AFB, Ohio

Research to establish the capability and advantages of electron beam welding methods as a practical fabrication process for conventional structural alloys readily fabricated by traditional welding methods. Requests for this RFP must be in writing. Address requests to Systems Engineering Group, Attn: NOTE Colon SEKRB, Wright Patterson AFB, Ohio, 45433. RFP 180073-R-B.

Directorate of Research and Development Procurement
Systems Engineering Group (RTD)
Wright Patterson AFB, Ohio

Negotiations will be conducted with Aerojet-General Corp., Azusa, Calif., to toxicological research on selected missile propellants and propellant constituents. This is a continuation of the work under contract AF 33(657)-10951. For information only. No RFPs available. PR NR 61136-MB.

Commanding Officer
Aberdeen Proving Ground, Md.

Negotiations are to be conducted with Thiokol Chemical Corp., Bristol Div., Bristol, Pa., for further research on an acoustic detection system. RFP-RD-APG-64-64. Note: For information only; RFP not available.

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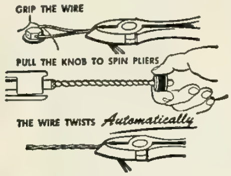

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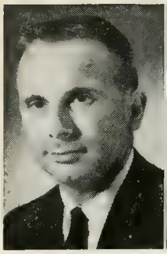
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William S. Henry, Jr.: Appointed manager of Philco Corp.'s Aeronutronic Div. Marketing Office, Newport Beach, Calif.

William G. Fisk: Appointed technical representative for Haveg Reinhold Inc., Santa Fe Springs, Calif.

John L. Boyer: Named senior engineering consultant at International Rectifier Corp., El Segundo, Calif.

Gerard Decker: Appointed manager of systems applications for the Data Systems Div. of Litton Industries, Canoga Park, Calif.

James A. Luksch: Appointed director of engineering at Telonic Industries, Beech Grove, Ind.

Dr. Robert B. Mears: Named vice president-new product development for United States Steel Corp., Pittsburgh.

Frank Gard Jameson: Appointed vice president and assistant to the president of Ryan Aeronautical Co., San Diego, Calif.

Lloyd R. Morrow: Named product manager in charge of relays and electrical components for Cook Electric Co.'s Wirecom Div., Chicago.

Vince Neeson: Announced as president of the newly-formed Neeson Co., San Francisco. **D.J. Spencer** appointed vice president-production and **Major James F. Neeson** (USA Ret.) named vice president and resident manager of the Monterey, Calif., division.

Dr. Seymour Blum: Appointed director of research-ceramics operations of ITT Research Institute, Chicago.

David Westerman: Elected director and president of Hazeltine Research, Inc., Chicago.

Anthony R. Pignoni: Appointed New York area marketing representative for the Nortonics Div. of Northrop Corp.

David J. Gibson: Named manager of development and engineering at Dynatech Corp.'s Instruments and Measurements Dept., Cambridge, Mass.

Reuben O. Schlegelmilch: Named manager-advanced missiles programs, Space Guidance Center, International Business Machines Corp., Owego, N.Y.

Daniel J. Youngerman: Appointed manager of procurement and facilities planning for Sylvania Electronic Systems Div. of Sylvania Electric Products Inc., Waltham, Mass.

Herbert F. Lello: Named executive vice president-manufacturing of General Telephone & Electronics Corp., New York City.

Arthur S. Rosenthal: Appointed manager-systems and data processing at the Norden Div. of United Aircraft Corp., Norwalk, Conn.

George D. Pugsley: Appointed western district regional manager for Electronic Communications, Inc., North Hollywood, Calif.

Charles Hummel: Elected a vice president of the Bendix Corp., Detroit.

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JANUARY

10th National Symposium on Reliability and Quality Control, Statler Hilton Hotel, Washington, D.C., Jan. 7-9.

National Society of Professional Engineers Winter Meeting, Westward Ho Motel, Phoenix, Ariz., Jan. 8-11.

1964 Annual Automotive Engineering Congress and Exposition, Cobo Hall, Detroit, Jan. 12-17.

146th National Meeting of the American Chemical Society, Denver, Jan. 19-24.

Aerospace Sciences Meeting, Hotel Astor, New York City, Jan. 20-22.

American Physical Society Conference on Semimetals, Columbia University, New York City, Jan. 21.

American Physical Society Meeting, Statler Hilton Hotel, New York City, Jan. 22-25.

SBA-SAVE Value Engineering and Analysis Symposium, Americana Hotel, New York City, Jan. 23.

American Mathematical Society 70th Annual Meeting, Miami, Jan. 23-27.

Second Annual Symposium on Fundamental Phenomena in the Materials Sciences, Sheraton Plaza Hotel, Boston, Jan. 27-28.

Conference on Control and System Optimization, Naval Post Graduate School, Monterey, Calif., Jan. 27-29.

AIAA Solid Propellant Rocket Conference, Palo Alto, Calif., Jan. 29-31 (semi classified).

American Meteorological Society 44th Annual Meeting, University of California at Los Angeles, Jan. 29-31.

FEBRUARY

American Institute of Chemical Engineers 52nd National Meeting, Hotel Peabody, Memphis, Tenn., Feb. 2-5.

IEEE Winter Power Meeting, Statler Hilton Hotel, New York City, Feb. 2-7.

International Congress on Documentation and Scientific-Technical Information, Rome, Italy, Feb. 2-11.

International Conference on the Impact of Modern Physics on Materials, Sheraton Hotel, Philadelphia, Feb. 3-7.

IEEE-MIL Fifth Winter Convention on Military Electronics, Ambassador Hotel, Los Angeles, Feb. 5-7.

American College of Radiology National Meeting, Tucson, Ariz., Feb. 5-8.

Institute on Information Storage and Retrieval, sponsored by American University, International Inn, Washington, D.C., Feb. 10-14.

Golden Gate Metals Conference, San Francisco, Feb. 13-15.

1964 Annual Meeting and Symposium on Physical Metallurgy of Refractory Metals, sponsored by AIME, New York City, Feb. 16-20.

ASCE Transportation Engineering Conference, Netherland Hilton Hotel, Cincinnati, Feb. 17-21.

International Solid State Circuits Conference, sponsored by IEEE and University of Pennsylvania, Sheraton Hotel and University of Pennsylvania, Philadelphia, Feb. 19-21.

9th Scintillation and Semiconductor Counter Symposium, sponsored by IEEE, AEC and NBS, Shoreham Hotel, Washington, D.C., Feb. 26-28.

MARCH

ASME Gas Turbine Conference and Products Show, Shamrock Hilton Hotel, Houston, Mar. 1-5.

Atmospheric Problems of Aerospace Vehicles, sponsored by FAA and AMS, National Aviation Facilities Experimental, Atlantic City, N.J., Mar. 2-5.

15th Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Penn-Sheraton Hotel, Pittsburgh, Mar. 2-6.

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Sound, Not Fury

WE WISH President Johnson well in the New Year but we also wish he would cut out the political sleight of hand with the Dept. of Defense budget. He's not fooling anyone.

DOD last week noted that Secretary McNamara, at the direction of President Johnson, had cut $9 billion from the Fiscal '65 defense budget.

The fact of the matter is that this is a perfectly normal review procedure and was already planned. Last year, for example, Secretary McNamara cut more than $13 billion from the service requests before sending the budget to President Kennedy.

In order to improve chances for a tax cut, President Johnson naturally would like to have it appear that he has instituted some $9 billion in savings. But this just isn't true.

Furthermore, the confusion from these claims is resulting in considerable uneasiness in the industry as the year opens.

Recent cutbacks in a number of projects—*Dyna-Soar, Ranger* and *Rover,* as examples—have contributed to this feeling.

But we are confident that presentation of the new budget to Congress will end this period of uncertainty. The economic strength of the missile/space industry depends not upon individual programs but on the long-range national philosophy behind those programs.

President Johnson has made it more than evident that he firmly backs the military and space philosophies which have brought this industry to its present position as No. 2 in the nation. This will be made clear in the budget which the President presents to Congress later this month.

Lockheed Aircraft Corp. in a recent statement before a subcommittee of the Senate Labor and Public Welfare Committee put forward this view of the future:

"Our own forecasts all point to a continued high level of defense and space spending in view of the basic realities of the present world situation. It seems to us reasonable to expect a nearly constant level of combined defense and space spending over the next few years or, at the most, only a slightly declining one. Recent estimates of a $5-billion decline in defense spending over the next five years appear to us as a valid but perhaps outside figure, more likely subject to downward rather than upward revision. We should think that civilian space spending may hold steady or perhaps increase."

We believe this Lockheed forecast to be, if anything, somewhat pessimistic. We consider a $5-billion decline in defense spending as highly unlikely. There already are certain evident trends which suggest this.

One, which has gone largely unnoticed publicly, is a reversal in Soviet strategy which now appears to be under way. The Soviet Union, as we noted last month (M/R, Dec. 2, p. 18), seems to be at the beginning of a new buildup of its ICBM forces.

With the intercontinental missile forces of the U.S. growing rapidly, the Dept. of Defense lately has been putting more emphasis on the needs of conventional warfare. This will be reflected in the new budget. At the same time, however, some consideration must be given to the new Soviet direction. If there is firm evidence of a belated boost in production and emplacement of Russian ICBM's, Secretary of Defense McNamara and his staff must take a new look at U.S. anti-ICBM planning. The U.S. has been able to postpone extensive funding of an AICBM program because of the failure of the Russians to produce as many ICBM's as anticipated. Once again, we would like to point out that there was indeed a Missile Gap, although its existence now has been derided by many critics. The gap existed in potential—the badly-neglected production plans of the U.S. That it did not develop in actuality was due to two factors, one which we controlled and one which we did not: a U.S. speed-up and a Soviet slow-down in ICBM emplacement. Those who demanded an increase in U.S. production because of a Missile Gap were entirely correct. The gap would have been clear if the Soviets had implemented their production potential and we had not.

Unless the Soviet buildup is further along than we believe, we do not anticipate extensive *Nike-X* funding in the Fiscal 1965 budget to be sent to the Hill. But it could very well be a factor in the Fiscal '66 budget.

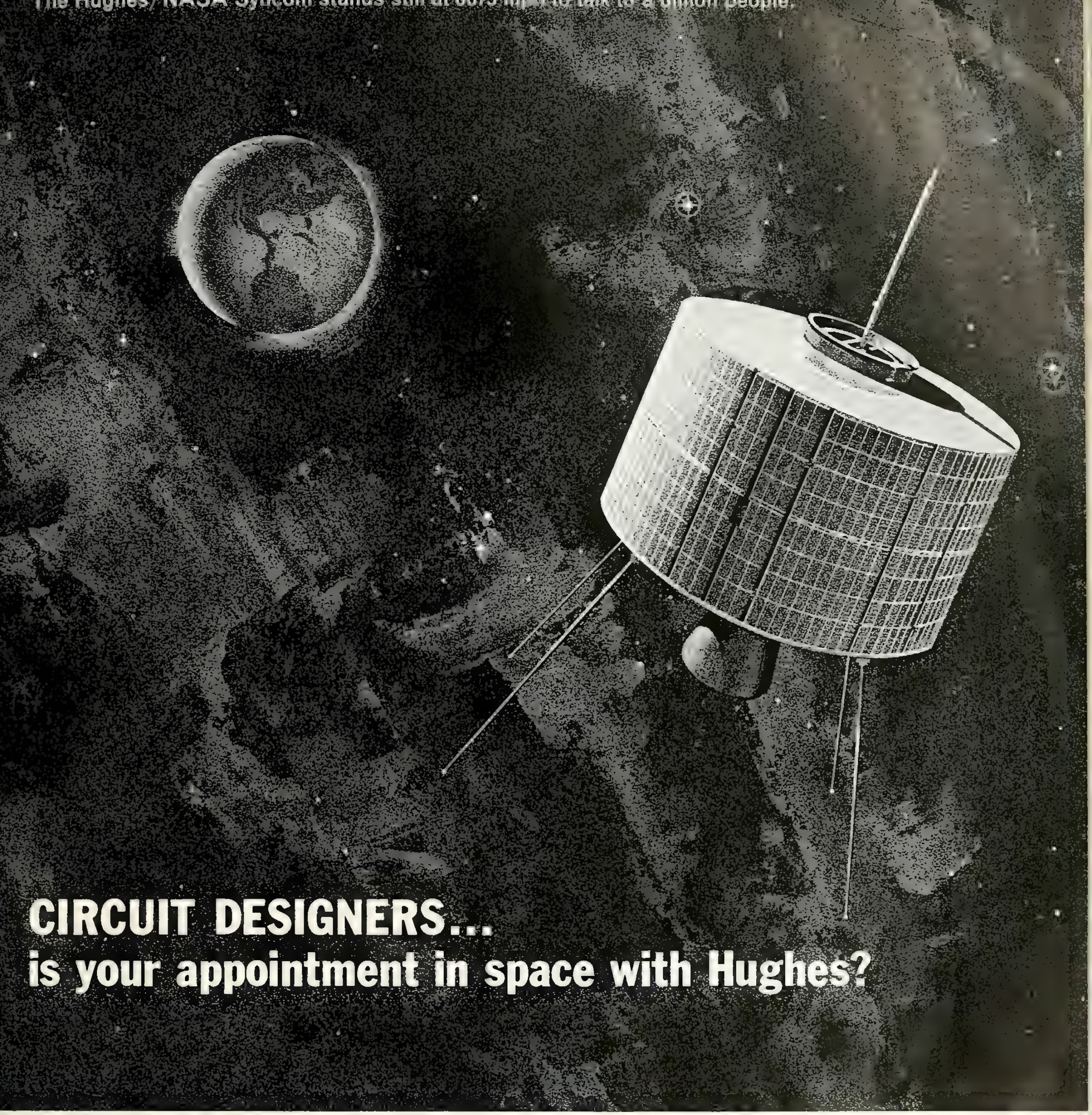
LAST JANUARY, the Congressional Joint Economic Committee released a report by more than 20 academic experts on the Soviet Union which insisted that the Russians lacked the capability to support ICBM production, missile defenses and the space effort simultaneously. The Soviets, said these experts, could afford only one of these alternatives. Since a large space effort was in progress, it was noted that this clearly had been the choice over the other two. At that time, we called the report so much academic hogwash. We warned then that if the Administration decided not to build anti-ICBM defenses in a belief that the Soviets were incapable of an ICBM buildup while simultaneously carrying on a space program, it was toying with national survival.

This is equally true today and it is a situation which the new Administration must face.

Another factor which will tend to increase defense spending is the implementation of a manned military space program of such a nature that there is no limitation on its potential. Because there have been many in high places in the Pentagon who have not understood the need for this in the past, we doubt if they realize what it is they have now begun. The advent of military man in space will produce many requirements for well-funded military activities there. *Gemini-X*, we predict, will be the first of a long line of Air Force operational space vehicles.

The industry should keep in mind the fact that much of the sound and fury is political. It is not short-range individual projects, but long-range national objectives upon which the industry's strength rests. And these are secure.

William J. Coughlin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JANUARY 13, 1964

missiles and rockets

HE WEEKLY OF SPACE SYSTEMS ENGINEERING

Budget Cuts No Threat to Most Programs

Navy Considers 'B3' Polaris

PERT-Type Profit Checking

Latest Edition Of M/R Astrolog

Mated Saturn SA-5 Awaits Launch at Cape

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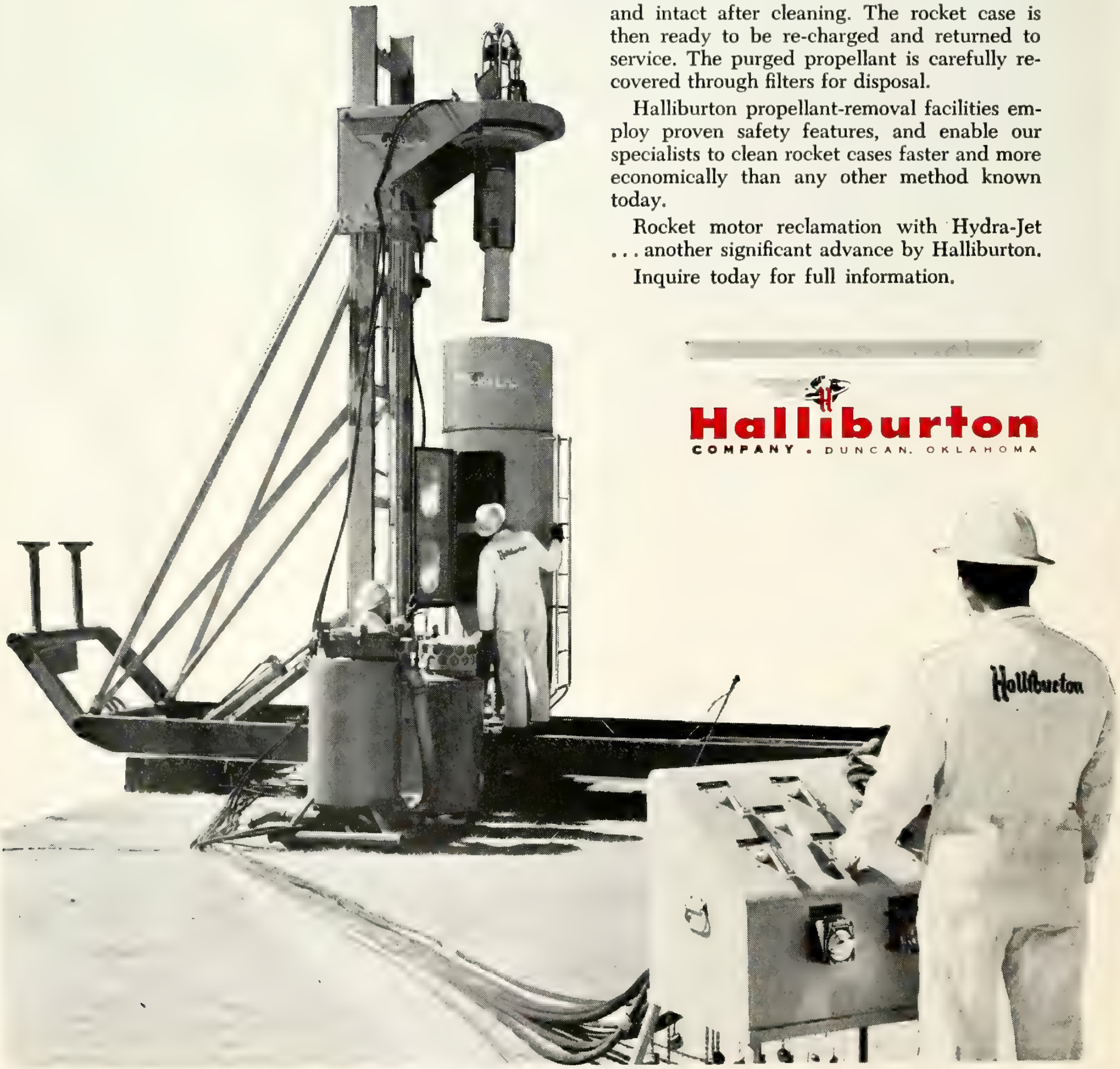

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But we can improve man-machine efficiency by designing vehicles "around" him. One major obstacle—replacing man's subjective impressions with quantitative test data—has been overcome by a new achievement of Caterpillar research.

Human memory was too unreliable.

Even our best test drivers couldn't exactly record their reactions during field tests. And precise data was what we needed.

Our first project was to develop instrumentation for recording the effects of motion, vibration, balance, noise and seat position on vehicle operators.

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When these devices were operational, we tackled the job of developing testing methods which would duplicate identical conditions in a controlled laboratory environment. The result was the Caterpillar Ride Simulator.

This device has three basic elements: a ride platform, including seat and controls; a servo drive mechanism which controls the platform; and an analog computer which directs the servo drive unit.

We can record on tape vertical acceleration measurements of a vehicle in the field . . . and then recreate them exactly on the ride platform in the lab.

No Memory Problem

Now we can study the effects of vehicle parameter changes more closely. And we can judge two versions of a vehicle in immediate sequence—eliminating the ride memory problem completely.

Step 3 of our human engineering project was even more ambitious. Could we shortcut vehicle development by evaluating prototype designs with pre-hardware paper testing?

Using the analog computer, our research engineers simulated a mathematical "model" of a vehicle concept. A taped road profile was used as input data to the model with the computer output actuating the ride simulator.

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Instant Design Changes

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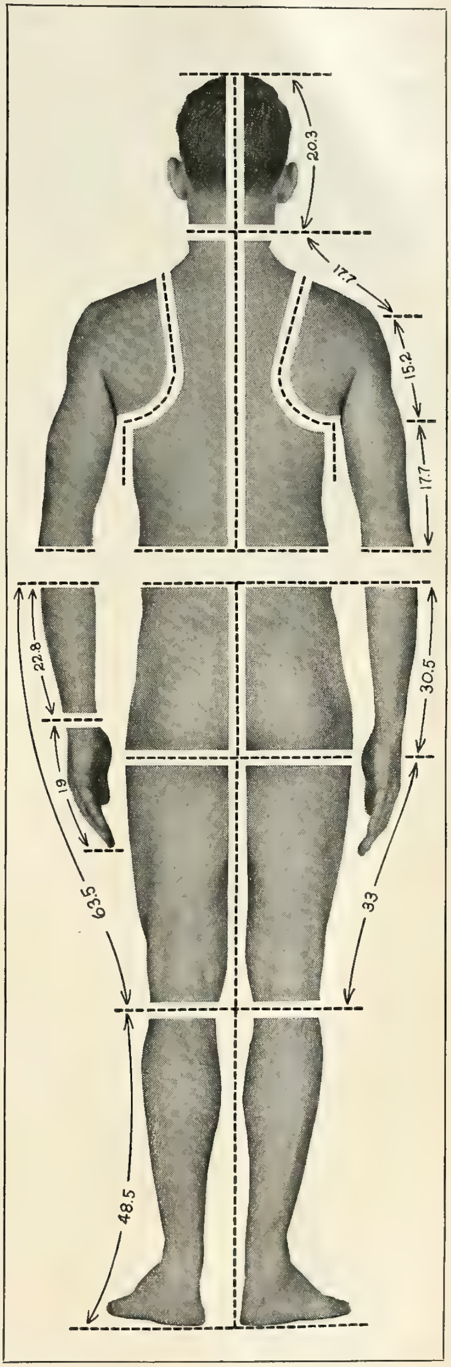
Accuracy? No problem.

How important will the Ride Simulator be in our future R & D work?

The time saved in evaluating existing hardware alone will be highly rewarding—to say nothing of its potential in the evaluation of new vehicle concepts.

The Ride Simulator is only one example of Caterpillar's continuing study of Human Engineering as a means of perfecting the man-machine relationship. The vehicle specialists at Caterpillar can apply this special knowledge to your military vehicle projects. Contact Defense Products Department, Caterpillar Tractor Co., Peoria, Illinois.



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THE WEEKLY OF SPACE SYSTEMS ENGINEERING

Volume 14, Number 2 January 13, 1964

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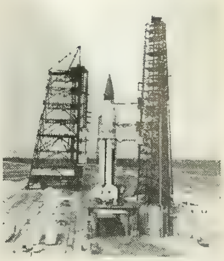
THE COVER



Fully mated SA-5 Saturn launch vehicle stands on newly constructed Launch Complex 37 at Cape Kennedy, awaiting launch now scheduled for Jan. 29. This is first Saturn I vehicle in which second stage is live and will be placed in Earth orbit.

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48,000 copies this issue

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AEROSPACE CORPORATION

Organized in the public interest and dedicated to providing objective leadership in the advancement and application of space science and technology for the United States Government

letters

SA-5 Payload

To the Editor:

Re M/R, Dec. 16, p. 18, article on *Saturn SA-5* . . .

In other magazines, I expect it; in M/R, *never!*

I quote:

"The flight is also designed to put into orbit a 37,700-lb. payload, the world's heaviest to date."

Oh, come now, are we to go through the routine once again of classifying the whole bloody package as *payload?* Like we did with Project *Score*—with 150 lbs. payload and the whole empty *Atlas* weighing 8,600 lbs. all listed as *payload!*

This may come from NASA (Score data sheet S-58-13) . . . from politicians . . . from uninformed newsmen and periodicals, but *please,* not from M/R, which has led a long struggle for accuracy.

On the basis of the actual 16,900-lb. payload capability of *SA-5,* just imagine, then, the total weight put into orbit when *Sputniks VIII* and *VII* went up with payloads of 14,292 lbs. some three years ago . . . *SA-5* is supposed to be fabulously efficient, especially with the S-IV use of hydrogen. Yet, *SA-5* will orbit a payload only some 2,600 lbs. heavier than those "crude, inefficient and clumsy" Russian rockets of February, 1961.

How heavy, then, the complete *weight-in-orbit* of the heavy *Sputniks* . . . of the 10,400-lb. *Vostoks* (payload), etc.?

But let's at least keep *our* records straight!

Martin Caidin
Plainview, N.Y.

Reliability 'Methods'

To the Editor:

In reference to your Dec. 23 (p. 14) article concerning reliability and quality assurance, we were shocked and dismayed by the misleading headline used, viz., "Golovin Cites Hazards of Reliability Methods." Actually there is no connection between the headline and the message which Mr. Golovin wished to convey as delineated in his quotes. Alterations in budgets and organizational tinkering are management prerogatives and have no relationship to the soundness of reliability methods.

We who are striving to get acceptance of reliability and quality assurance concepts and practices in industry are having enough difficulty in converting a generation of design engineers, test engineers, executive managers, etc., to the idea of providing adequate moral and monetary support to reliability and quality assurance programs, without an esteemed publication such as M/R implying that basic reliability and quality assurance methods are suspect.

D. E. Hartvigsen
George Miller
Members of Industry's Reliability
and Quality Assurance Team

We feel that management (or mismanagement) practices in the reliability area are "methods" just as much as are the engineering techniques involved. Certainly M/R is not opposed to the indispensable work being done by Messrs. Hartvigsen and Miller and their confreres.—Ed.

NOL and Subroc

To the Editor:

In reading your otherwise complete article on *Subroc* (M/R, Dec. 9, p. 12) I was impressed by the lack of mention of the technical direction agency. I am therefore curious as to whether you have a policy against mentioning government laboratories for the accomplishments in research and development.

G. K. Hartmann
Technical Director
U.S. Naval Ordnance Laboratory
White Oak
Silver Spring, Md.

M/R has no such policy; indeed, we endeavor to mention technical direction agencies in all articles. The failure to cite NOL was inadvertent.—Ed.

'Profile Of An Industry' Reprints

IN RESPONSE to widespread reader interest, MISSILES AND ROCKETS *has prepared reprints of the three-part "Profile of an Industry" series by Senior Editor William Beller. Based on recent surveys by U.S. Government agencies and the Stanford Research Institute (under a contract from the Aerospace Industries Association), the articles first appeared in the Oct. 28, Dec. 2 and Dec. 16, 1963, issues of M/R. Together they provide an unprecedented report on the growth of the Missile/Space industry—now the second largest employer in the United States—and its impact on the national economy and technology.*

The twelve-page reprint may be ordered from:

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Price of the reprint is $.50 (fifty cents) per copy.

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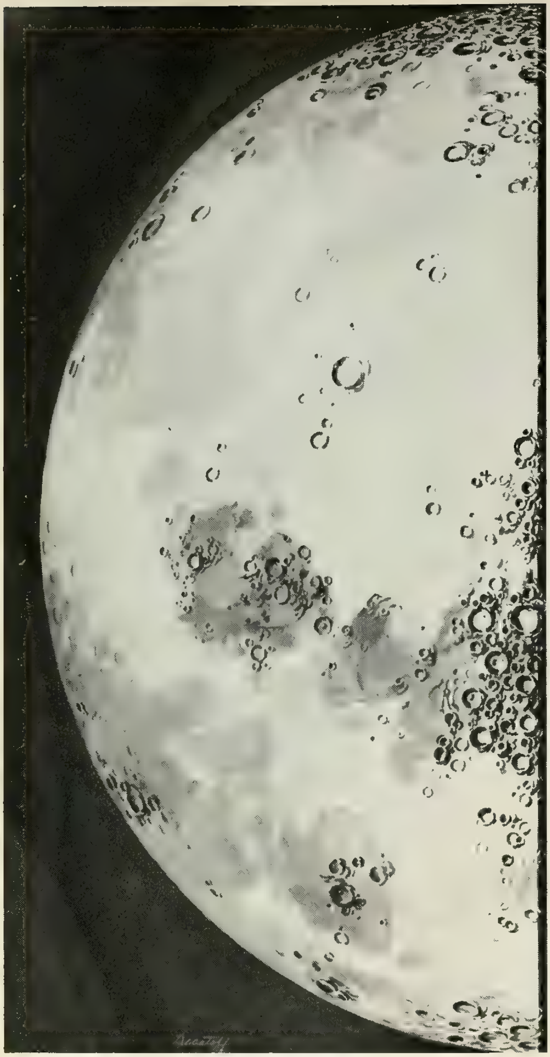
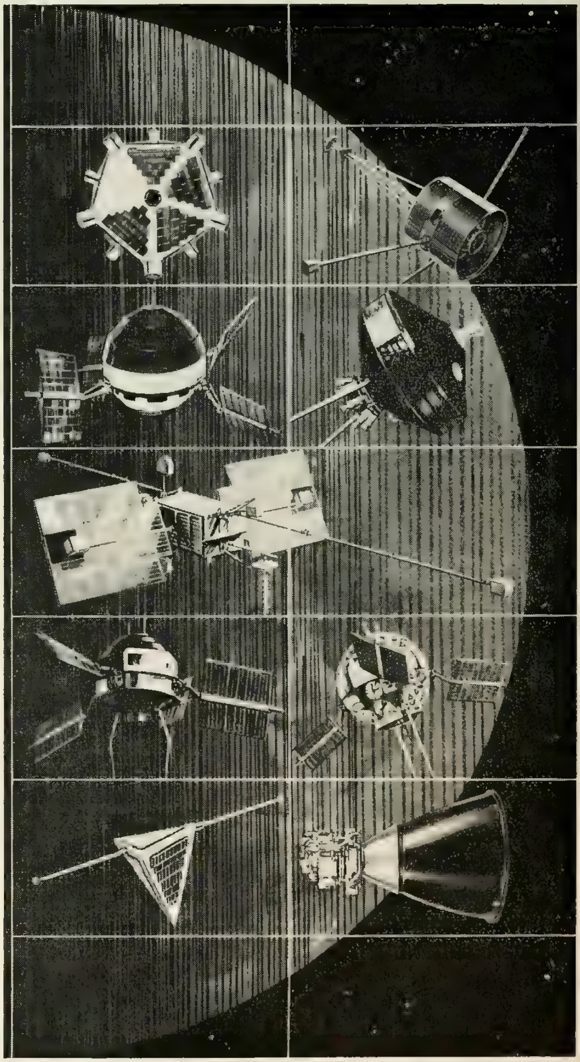


As the nation's first industrial firm devoted exclusively to missile and space technology, TRW Space Technology Laboratories grew with the national space effort. Since 1957, STL has participated in nearly every manned and unmanned space probe.

Today, 2500 engineers and scientists and 4500 support personnel combine their talents on many STL projects ranging from research and development to design and manufacture of NASA'S OGO spacecraft, Air Force nuclear test detection spacecraft, Tetrahedral Research Satellites, and NASA'S Pioneer spacecraft.

Also underway is the development of the variable-thrust rocket descent engine for LEM, the Lunar Excursion Module of Project Apollo. At the same time STL continues Systems Management for the Air Force's vital Atlas, Titan and Minuteman Programs.

These many space activities create immediate openings for engineers and scientists with experience in Theoretical Physics, Systems Engineering, Radar Systems, Experimental Physics, Applied Mathematics, Space Communications, Space Physics, Antennas and Microwaves, Inertial Guidance, Analog Computers, Solid State Physics, Computer Design, Telecommunications, Digital Computers, Guidance and Navigation, Electromechanical Devices, Engineering Mechanics, Applied Aerodynamics and Propulsion Systems.



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TRW SPACE TECHNOLOGY LABORATORIES
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The Countdown

WASHINGTON

Redeye Into Production

Army has received a production go-ahead for its *Redeye* missile, a hand-carried defense weapon for the combat infantryman against low-flying aircraft. Decision to produce followed solution of problems which had caused slippage of more than two years. General Dynamics/Pomona is prime contractor.

Tracking Ship Squabble Settled

NASA and DOD have resolved their differences over the number of new tracking ships required for Project *Apollo*. Three new ships will be built and two others modified. The three new vessels will be used during insertion of the flight phase of the mission to the Moon and back. The two modified ships will command the re-entry phase.

MMRBM Gains Phase II

The *Mobile Medium Range Ballistic Missile* has moved another step in its touch-and-go existence with an industry team beginning work on the development phase. Final contract negotiations are under way. In its program definition phase the *MMRBM* shaped up as a truck-mounted, solid-propellant, air-transportable missile and launcher with possibilities for shipboard mounting.

Manned-Gemini-in-'64 Push Begins

A major drive is on to make the first manned *Gemini* flight in 1964. As a result, space agency officials have made an earlier-than-expected start on installation of aerospace ground equipment at Cape Kennedy's Launch Complex 19. Originally, the work was not expected to begin until after the first manned flight, late in February or in March.

Beyond-Saturn Vehicles Investigated

Martin Co. and NASA have signed a $1,499,111 contract for a Part II study of post-*Saturn V* launch vehicles. The one-year study will include overall vehicle definition and preliminary design.

F-1 Flight Rating Snarled

NASA's budget squeeze has delayed the Preliminary Flight Rating Test (PFRT) of the F-1 engine until the summer of 1964. This is more than a year after the first scheduled date, March, 1963. The first delays were caused by the combustion instability problem which was subsequently solved. Now officials report that funding shortages have delayed the *Saturn V* project, so NASA is using the time to get a modified F-1 ready to run through the PFRT.

M-1 Funding Continues Austere

The M-1 liquid hydrogen engine will be funded in FY '65 at approximately the same level as the current year, $25 million. This could be reduced if Congress makes heavy cuts in the budget, but NASA wants to hold it at the current level, which it believes to be the lowest possible if the program is to continue as an engine development project.

INDUSTRY

260-in. Solid Considered for Saturn S-IVB

NASA's Huntsville, Houston and Washington offices have been discussing proposals to use the half-length, 260-in. solid rocket engine to boost the *Saturn* S-IVB stage, rather than the presently planned J-2 liquid engine. Big-solid experts estimate that the move might cut costs by 40%. Some further use of the half-length 260-incher in the *Apollo* program has also been proposed. One industry spokesman says he sees slippage in the *Apollo* time schedule as a result of NASA budget problems, "so this is a chance to use new concepts at a savings." Both Aerojet-General and Thiokol, which hold 260-in. half-length contracts, have new large-solid casting, curing and test facilities under construction.

A-G Plant Expects Sales Drop, Will Expand

Aerojet-General's operation in Sacramento is cutting back its work force as a result of Federal budget uncertainty and the fact that emergency aspects of programs such as *Polaris, Minuteman* and *Titan* are over. The company expects a sales drop of 5-10% this year, and plans to release some 1,000-2,000 persons from its payroll during the year. Normal attrition will account for much of the reduction, however, and one official says the total effect of budget and cost cutting at Sacramento will be minor. The company is embarking on an $18.3-million expansion of its plant, where the present investment is $170 million.

NASA Rumored Seeking Ehricke

There are reports in the industry that Krafft Ehricke, of General Dynamics/Astronautics, has been offered a high-level job at NASA. As of late last week, there was no confirmation from either Ehricke or the space agency.

INTERNATIONAL

Radiation, Inc. Licenses French Company

Radiation, Inc., of Melbourne, Fla., has announced that it will license a French firm—Intertechnique—to manufacture and sell airborne PCM telemetry in Common Market nations, Israel, and all NATO countries except the United Kingdom.

MSBS Tests Slated for Pacific

The 3,500-ton French experimental submarine Gymnote, which will be used to test the electronic equipment, inertial guidance system, and launching tubes of the French atomic submarines, will be launched March 15. Ship will be equipped with four launching tubes. Testing of *MSBS* missiles, French-developed counterpart of *Polaris*, will take place in the Tuamotu (Pacific) Range of the French Navy.

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The Missile/Space Week

Davis Heads Range Division

A new unit to coordinate and manage activities on Air Force missile ranges has been activated at Patrick AFB, Fla., by the Air Force Systems Command.

Maj. Gen. Leighton I. Davis, commander of the Air Force Missile Test Center at Patrick, was named to head the National Range (NRD), Provisional, which will become fully operational on July 1.

The activation order, dated Jan. 2, 1964, also created the Air Force Space Test Center, Provisional, with headquarters at Vandenberg AFB, Calif.

At the same time, a headquarters AFSC range office was established in the office of Maj. Gen. O. J. Ritland, Deputy Commander for Manned Space Flight.

Brig. Gen. Harry J. Sands, Jr., vice commander of AFMTC, was chosen to replace Davis; Brig. Gen. Jewell Maxwell, commander of the 6595th Aerospace Test Wing, was named head of the new AFSTC.

AFSC spokesmen said the NRD will coordinate and manage activities on the present Atlantic Missile Range and those portions of the Pacific Missile Range which are to be transferred from Navy to Air Force control.

Sperry Gets U.K. Polaris Pact

Sperry Gyroscope Co. has received $4,325,000 to begin management of design, manufacture and installation of navigation systems for the British *Polaris* missile submarines presently planned by the Admiralty. Total funding to Sperry for British *Polaris* management and equipment is expected to total close to $10 million over several years.

Great Britain is to build the subs, their atomic power plants and the *Polaris* warheads. They will purchase from the U.S. the missiles and such related equipment as fire control and navigation systems.

Present plans call for four subs, the first to be operational within five years. The vessels are expected to be comparable to U.S. craft of the 425-ft., 7,000-ton Lafayette class and will carry much of the same fleet ballistic missile equipment.

Sperry will produce the radio navigation equipment, navigation data assimilation computers, navigation control consoles, checkout consoles and high-speed repeater units to transfer navigation data to the missile fire control system.

System May Refine BMEWS

A new facet of the U.S. early warning system came to light last week with the disclosure that a technique apparently involving the use of an advanced microbarograph has detected the combusion of rocket launches as sharp upturns in barometric pressure.

Reports are that the system was successfully used to detect the exact time of Soviet missile launches over the Pacific last year.

There is a dearth of official information on the device, but the following possible explanation was offered by civilian scientists.

Explosions such as those of rocket launch combustions create a sharp upturn in barometric pressure, which spreads wavelike from the source, diminishing with distance traveled. A network of microbarograph stations, possibly providing a grid pattern of coverage over parts of the USSR, could detect an unusually sharp pressure rise, identify it as characteristic of a change produced by a rocket launch (easily distinguishable from a jet plane takeoff, for example), and then locate fairly accurately the site of launch origin.

Shots of the Week

The Navy launched a *Polaris A3* missile from a Cape Kennedy land pad Jan. 7. The purposely short flight was termed a success. The shot was the 14th success in 23 land launches of the advanced weapon.

- NASA test pilot Joe Engle ran into trouble in an *X-15* flight Jan. 8 near Edwards AFB, Calif., when the ship's inertial guidance system failed, but landed the rocket plane safely with assistance from a ground control station.

LEM Award Goes to Ryan

Ryan Aeronautical Corp. has been selected by Radio Corp. of America to design the landing radar for the Lunar Excursion Module. RCA is responsible for major subsystems for LEM.

The radar is to provide data on LEM's altitude and velocity relative to the Moon's surface during landing approach.

RCA will integrate the landing radar with the overall sensor subsystem, which will include the rendezvous radar being designed and built by RCA to enable the astronauts to rejoin the parent *Apollo* spacecraft to return from the Moon.

Students Get NASA Funds

One hundred and thirty-one colleges and universities will participate in NASA's graduate training program for the academic year 1964-65.

Nearly 1,100 students will begin work on doctoral degrees in space-related areas under grants that will be received by schools located in 47 states.

Participants in space-related predoctoral studies will be selected by the universities and will enter the program in September, 1964. The number at each school will vary from two to fifteen, depending on the number of doctoral programs available in space-related fields, the adequacy of the school's facilities and extent of its participation in space activities.

Rice U. Enters Rocket Research

Rice University's new Space Science Department plans to launch the first in its "Sammy Series" of space probes starting Jan. 14 at Wallops Island, Va.

Prof. Brian J. O'Brien, formerly with Dr. James A. Van Allen at the State University of Iowa, will use a *Nike-Cajun* rocket to send a 50-lb. instrument package up to measure the light and particle energy in the night airglow over Wallops.

The other three Sammy shots will be fired from Fort Churchill, Manitoba, Canada, into auroras passing directly overhead. Dr. O'Brien will move into position at Fort Churchill about the middle of February.

The four-shot series is sponsored by a $200,000 NASA grant.

Relay Misbehavior Explained

Radio Corp. of America engineers say that colder-than-expected temperatures in the region where the *Relay I* communications satellite is operating are responsible for its failure to turn off when intended.

The action of a substance that was to have eaten its way through a vital electrical connection in the satellite has been retarded by the cold, the engineers theorize.

The vehicle, launched in December, 1962, continues to live on borrowed time, tying up radio channels now wanted for other purposes.

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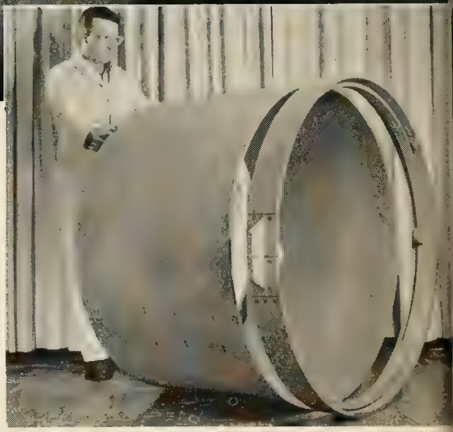
Titanium

Size is no object. Small titanium bottles, made by D-K Manufacturing Company, Chicago, from Wyman-Gordon Co. forgings, hold 150 cu. in. of oxygen at 3,000 psi and weigh only 3.65 pounds. On the other end of an almost unlimited scale of size is the titanium tank made from sheet metal by Beech Aircraft. It measures 8 x 24 ft., holds 7,000 gallons of liquid hydrogen, yet weighs only 473 pounds.



TITAN III oxidizer and fuel tanks. Ti-6Al-4V is used for upper-stage nitrogen tetroxide tank (46 x 174 in.) and the unsymmetrical dimethylhydrazine tank (63 x 154 in.). Shown above is one of the titanium roll forged cylinder sections and stiffener rings produced by Ladish Co. for Martin Company for use in tank construction. Final machining and welding are done *after* heat treatment, eliminating distortions and production difficulties inherent in many heat-treatable metals.

for tankage ... big or little, hot or cold

Compatible with space-age fuels . . .
readily available in a range of alloys . . .
fabricated from sheet or forgings . . .

In short, there are good, metallurgical reasons why titanium tanks and vessels—more than 5,000 of them—are aboard just about everything that flies today. They come in all sizes, handle all types of fuels and gases, save vital pounds, add stiffness and strength to structures. Here are a few of the reasons why:

High strength-to-weight. Titanium weighs 44% less than steel yet is stronger. It has a high yield strength, good ductility, notch toughness all the way down to *minus* 423F. It offers high buckling resistance at less weight than other metals.

Compatible with fuels and gases. Titanium shows outstanding resistance to liquid and solid fuels and oxidizers in use today or planned for the future. Its impermeability to hydrogen and resistance to sea-water and atmospheric corrosion mean thorough reliability and indefinite storage life.

Alloy availability. A variety of titanium alloys are available for tankage construction — two of them in Titanium Metals Corporation of America's ELI (extra low interstitials) compositions, developed specifically for liquid hydrogen service. Only TMCA can supply all titanium alloy grades in any commercial product or size required.

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For more information . . . write for new Data Sheet on titanium tankage. Write Technical Service Department, Titanium Metals Corporation of America.

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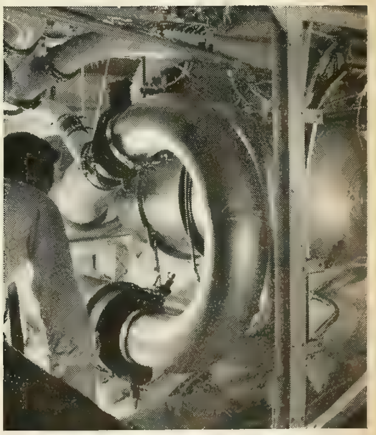
GEMINI Titanium pressure vessels. Vessels used throughout Gemini spacecraft are made from titanium to minimize deadweight which must be lifted off the ground. Shown here are titanium hemispheres hydroformed by California Hydroforming Company, Inc., El Monte, California. **APOLLO liquid hydrogen bottles.** Pressure vessels are produced from titanium alloy grade Ti-5Al-2.5Sn ELI to provide exceptional toughness to cryogenic temperatures. A typical bottle weighs only 12.9 pounds, has a wall thickness of 0.031 in.; at the weld girth, 0.044 in.



MINUTEMAN titanium second stage. Cylindrical sections possess great stiffness at minimum weight. Minuteman cases consist of roll forged cylindrical sections welded together. Titanium welds are as strong or stronger than parent metal, are less sensitive than steel to weld porosity and need no pre- or post-heating. **Titanium water bottle costs less than fiberglass,** weighs 17 pounds less than steel or fiberglass and is used on Boeing 727 as the most efficient way to save weight. Shown also in photo is titanium tubing for cabin heat system.

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Spending level may be same . . .

FY '65 DOD Budget $50 Billion

by David C. Breasted

PRESIDENT JOHNSON will send to Congress next week a defense budget $3.9 billion below President Kennedy's Fiscal 1964 request. It will, however, be some $1-2 billion more than Congress actually appropriated for FY '64.

The President will seek $49.737 billion in the new DOD budget, to be sent to Congress Jan. 21. This compares with the $53.6 billion in total obligational authority requested by his predecessor last January. These figures do not include foreign military assistance program funds, which President Johnson set at another $1 billion.

Congress approved last October a DOD authorization totalling $47.2 billion. The extent to which the Johnson request exceeds this figure will depend on the amount of money still available from previous years, but the request should work out between $1 and $2 billion higher.

It thus appears that the President is attempting to steer a course in defense spending which will keep it on approximately the same level, or slightly below current levels. By knocking the budget request down below the previous year's request before sending it to the Hill, Mr. Johnson may have a talking point which could bring the new budget through the Congressional mill without encountering cuts as severe as the nearly $2 billion which the House lopped from defense request this past session.

On the other hand, White House strategy might have to allow for lawmakers in a mood to campaign on an economy record.

In an election year, Congress could pick up and run with the economy issue beyond the desires of the Administration.

The McNamara-Johnson cuts, however, were expected to have only minor effects on the great majority of current missile/space programs.

But there were at least two major exceptions:

- **Typhon out**—DOD re-oriented the Navy's *Typhon* missile almost out of the picture. However, testing will continue with *Typhon* radar and control components, which showed promise, aboard the test ship USS Norton Sound.

The next move will be to develop a more advanced, and hopefully less costly, system which can be used on smaller vessels. The Navy would not say at this time what ideas it favors as a replacement for *Typhon*, but several alternatives are under consideration.

In addition to the 200-mile *Typhon* version for which the Bendix Corp. was prime contractor, R&D on a 75-mile version also went by the board, contrary to some reports.

About $230 million had been spent on *Typhon*, with $58 million allocated for FY '64. The latter funds, together with $4 million reprogrammed from other projects, will cover contract termination and the Norton Sound testing.

- **Other cuts**—The Administration also elected to drastically drop the number of *Minuteman* buys—to 50 in FY '65 from 150 in FY '64. Future plans call for buying at the rate of 50 a year until the ICBM total reaches 1,200, instead of the 1,300 reported to Congress last year.

Rationale for the move was reportedly based on accurate estimates of a drop in Soviet missile production, and greater capabilities in *Minuteman II*. At least part of the doubled payload of the RV-6 re-entry body, compared with the RV-4, is decoy capability. Defense Secretary Robert S. McNamara has ordered acceleration in *Minuteman II* emplacement.

Furthermore, the Defense Department plans to substantially curtail expenditures for nuclear weapon materials, beginning in FY '65. The huge capital expenditures involved in ICBM introduction in the past three years are now history, and the rate of warhead acquisition will decrease in the future, high Government officials pointed out. Shutdown of four plutonium reactors and a 25% cut in the production of fissionable uranium will result in savings of $50 million in FY '65, and $70 million in FY '66, with attendant savings in materials buying.

- **MMRBM, Redeye gain**—On the other side of the coin, DOD has approved progress of the off-again-on-again Air Force *Mobile Medium Range Ballistic Missile* into the development stage, using 1964 funds. There is optimism that development will continue in FY '65 on the project, whose continuation stood out in an atmosphere of "reorientations" such as that of *Typhon*.

In another move, DOD decided to let the Army go into production of the man-portable *Redeye* antiaircraft missile for frontline troops.

The future of Army's *Mauler*, a track-mounted antiaircraft missile with radar guidance, clouded in the FY '65 picture as the Army began a tough look at the weapon to see if it is likely to work before moving out of engineering models into advanced models. ■

Missile/Space Highlights of President's Address

PRESIDENT Lyndon B. Johnson's first State of the Union address on Jan. 8 revealed a total U.S. budget of $97.9 billion, and made these points:

- There will be a reduced defense budget, but it will maintain "that margin of military safety and superiority obtained through three years of steadily increasing both the quality and quantity of our strategic, conventional and anti-guerrilla forces."
- With this budget, there will be the "lowest number of civilian personnel in the Department of Defense since 1950."
- The U.S. will make new proposals at Geneva "toward the control and eventual abolition of arms. Even in the absence of agreement we must not stockpile arms beyond our needs or seek an excess of military power that could be provocative as well as wasteful." Johnson revealed the cutback of uranium production by 25%, shutting down of four plutonium piles, and closing of many non-essential military installations.
- The President reaffirmed the goal of a lunar landing in this decade "in cooperation with other powers if possible, alone if necessary."
- He recommended legislation creating a tripartite industry committee to determine, on an industry-by-industry basis, where a higher penalty rate for overtime would increase job openings without unduly increasing cost—and authorizing the establishment of such higher rates.

FY '65 Space Request Is $7.2 Billion

THE JOHNSON Administration will ask Congress next week to authorize new Fiscal '65 spending of about $7.2 billion for the U.S. space program.

The biggest chunk will be a $5.326-billion request for NASA that will primarily pay for the cost of the U.S. lunar landing program.

DOD's space budget will be little changed from its Fiscal '64 request of $1.667 billion, although a slight increase is expected. The remainder will be split between the Atomic Energy Commission and the Weather Bureau.

The space agency will also request a Fiscal '64 supplemental appropriation bill of $141 million, bringing its new request for the two fiscal periods to $5.467 billion (M/R, Jan. 6, 1964, p. 12).

That total conceivably may still enable the space agency to meet its goal of landing a man on the Moon by 1970, but it will not support hardware development of a host of current and planned future space projects.

These include *Voyager, Advanced Pioneer*, the advanced *Fire Re-entry* project, flight-testing of the *SNAP-8* nuclear power unit program, the *Advanced Synchronous Communications Satellite*, a liquid fluorine stage. There will also be no funding for the RIFT (Reactor in Flight Test) project which was cancelled late last year.

The M-1 liquid hydrogen engine—which had been in danger—has thus far survived the budget-cutting shears. It is ticketed for about $25 million in next year's budget, just about this year's rate. Another $14 million will be included for the large 260-in. solid motor demonstration program recently acquired from DOD by NASA.

- **Same target date**—The NASA total is more than $300 million below the $5.8-billion figure which Administrator James E. Webb declared was necessary if the nation was to meet the 1970 goal for a manned lunar landing.

President Johnson, however, in his State of the Union message assured Congress that the U.S. would become pre-eminent in space, including successful achievement of the national lunar goal.

Almost two-thirds of the agency's FY '65 budget will be used to finance Project *Apollo* and *Gemini*, with slightly over $3 billion ticketed for manned space flight.

The same situation obtains in the supplemental request, which will be entirely assigned to the manned space flight projects with $110 million for the *Saturn V* and $31 million for the *Apollo* spacecraft. Some of the latter will be used to fund backup systems in the command, service and lunar excursion modules.

- **High hopes**—One of the big questions is how Congress will greet the space spending request during the current election-year request.

First indications from Congressmen were optimistic.

One high-ranking Democrat said that the House Appropriations Committee probably will receive favorably the National Aeronautics and Space Administration's request for a $141-million supplemental budget.

"I don't think there's too much resistance," Chairman Albert Thomas (D-Tex.) of the Independent Offices subcommittee told M/R. "But we'll have to take a careful look at it."

The Congressman added that he felt that by and large NASA was doing an "excellent job" of trying to economize to meet its considerably clipped budget. However, Chairman Clarence Cannon (D-Mo.) of the Appropriations Committee said earlier that he was opposed to any agency coming back for supplemental funds.

Chairman George P. Miller (D-Calif.), chairman of the House Space Committee, said "I think we'll have a reasonable chance of getting the supplemental through." Miller added that when the committee made cuts in the NASA budget the feeling was that NASA would be given a supplemental if it could justify it.

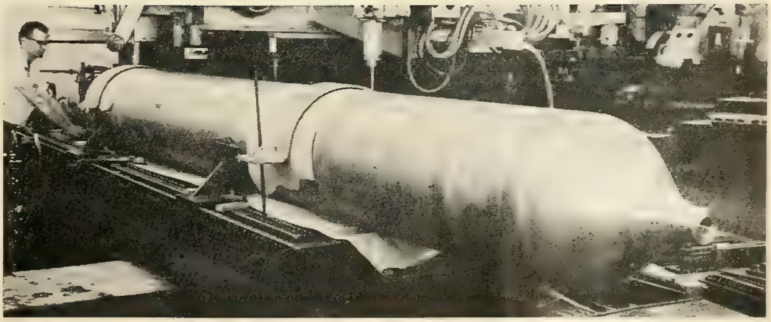
Rep. Olin Teague (D-Tex.) indicated that the supplemental request could have been even more, since the committee authorized $250 million more than was appropriated. "I've pushed for this supplemental all along," he said.

Miller termed the $5.326-billion FY 1965 budget request "fairly reasonable," and said it was in line with forecasts made in 1960. He said his committee would begin posture hearings to get things under way even before the FY '65 budget is sent to Congress. "I'm hopeful we can get the budget out perhaps sometime in April—that's the kind of target we'll set if we can get going soon."

Rep. Emilio Q. Daddario (D-Conn.) chairman of the research and development subcommittee, revealed that the Space Committee will have new tools with which to examine the science budgets. Besides an agreement just reached with the National Academy of Sciences by which scientists will be furnished to the committee for technical help, a new group of industry experts is being set up. ■

Saturn V Helium Bottle

FIRST OF 20 one-piece, high-pressure helium storage bottles for the Saturn V first stage rolls out of the Martin Co. production line. An $800,000 Martin contract with NASA calls for monolithic fabrication of the bottles from 2014 Alcoa aluminum alloy. Basic workpiece is a 22-in. extruded tube, which is beaten into shape through a new combination drop hammer-forging process. The bottles will contain liquid helium at pressures up to 3,000 psi.



Gemini Titan II firing due . . .

Gemini Model Readied for Water Recovery Testing

THE FIFTH *Gemini* static test model has been received by the Manned Spacecraft Center in preparation for water recovery tests in the near future.

In another important development, the first *Gemini Titan II* launch vehicle was scheduled for static test-firing at Cape Kennedy last week.

Both of the tests are important to the two-man space flight program's schedule, which calls for the first unmanned flight in the first quarter of this year and the first manned flight late in 1964.

MSC officials said the recovery and astronaut egress and entry tests would be conducted in the last week of February or early in March. The waterborne tests will be made in Galveston Bay or the Gulf of Mexico.

Prior to the tests, the spacecraft, which contains all on-board systems needed for recovery, will be tested in the static stand at MSC for about two weeks. Only the first 16 astronauts will take part in the project. The 14 other astronauts named last October will concentrate on Project *Apollo.*

The static test-firing of the *Titan II* launch vehicle was slated for no earlier than Jan. 10. The stages will be mounted side by side on separate mounts with each stage firing lasting about 30 sec.

Overall *Gemini* launch vehicle performance will also be evaluated. The U.S. Air Force Space Systems Div., through which NASA is purchasing the launch vehicles from Martin Marietta Corp., also is responsible for the development test and launch of the vehicle.

- **Parameters**—As the *Gemini* program moved toward the test phase preparatory to actual launches, MSC for the first time released official orbital parameters of the upcoming flights.

The first and second short-duration manned flights will have an apogee of 161 mi. and a perigee of 87 mi. The third and fourth manned flights will have a circular orbit of 161 mi., sufficient for a two-week flight.

The first attempt at orbital rendezvous will be attempted during the fifth flight, and it will also have a perigee of 87 mi. and an apogee of 161 mi.

For the rendezvous flights, the spacecraft will carry twice as much propulsion as it will carry for orbital flights. Extra oxygen will also be onboard.

Other details revealed by MSC include the 11-ft. overall length of the spacecraft at re-entry. Its height with the adapter will be 18¾ ft. Diameter of the adapter will be 90 in. at the spacecraft and 120 in. at the launch vehicle. The diameter of the heat shield, which will be jettisoned after re-entry, is also 90 in. ■

Team Wins Contract for Saturn V VAB

THE ARMY Corps of Engineers has announced it will award $80 million in construction contracts at the John F. Kennedy Space Center during this month.

The largest is a $63,366,378 award for the construction of the Vertical Assembly Building—to be the world's largest building—in which the *Saturn V* booster and the *Apollo* spacecraft will be integrated.

It is the biggest construction contract in the aerospace program and went to a three-firm combine of Morrison Knudson Co., Perini Corp. and the Paul Hardeman Construction Co., Inc.

The winning bid was the lowest of four submitted. U.S. Government estimate of the cost of the building was $61.2 million.

Total cost of the building, including equipment, is estimated by NASA at $100 million.

The VAB will have 145 million sq. ft. of space and will have four doors more than 450 ft. high.

- **Still to come**—The other bid proposals are scheduled to be opened at Cape Kennedy in the following order:

Jan. 8—Construction of roads, water lines and other utilities to serve the NASA *Apollo* spacecraft static test stand to be constructed on Merritt Island at an estimated cost of over $1 million.

Jan. 9—Construction on Merritt Island of a joint NASA-Air Force missile instrumentation station for frequency control and analysis. Estimated cost over $1.5 million.

Jan. 14—Construction of headquarters building for NASA's Launch Operations Center on Merritt Island. Estimated cost over $7 million.

Jan. 16—Construction of sterilization and assembly propellant test laboratory and instrumentation facility for NASA's Jet Propulsion Laboratory in Merritt Island launch area. Estimated cost over $1.2 million.

Jan. 16—Airmen's dining hall at Patrick AFB, Fla. Estimated cost more than $100,000.

Jan. 17—Construction of a three-story reinforced concrete central instrumentation facility for NASA on Merritt Island at an estimated cost of nearly $6.5 million.

Jan. 21—Auditorium and training facility for NASA's Merritt Island launch area. Estimated cost $400,000.

Jan. 22—Industrial water supply system for the Merritt Island launch area at estimated cost of $2 million.

Jan. 23—Water supply system for NASA's central telephone facility and south repeater station on Merritt Island. Estimated cost $90,000.

Jan. 28—Construction of missile fuel storage building and alterations to missile support structure and transmitter buildings at the Cape Kennedy Missile Test Annex. Estimated cost $270,000.

Jan. 29—Alterations to Complex 19 at the Cape Kennedy Missile Test Annex. Estimated cost $10,000.

Jan. 30—Construction of an electrical distribution system at the Cape Kennedy Missile Test Annex. Estimated cost $1.2 million.

AEC says . . .

Safe Design of Reactors Is Indicated

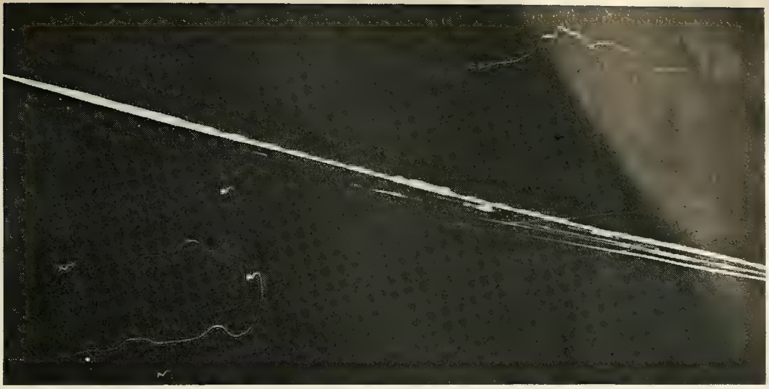


PHOTO OF streaks made by re-entry of mockup space reactor.

THE AEC SAYS nuclear space rectors can be designed to break apart nd disintegrate when they re-enter the Earth's atmosphere.

The commission said the statement was based on the first re-entry flight of a mockup space reactor called Re-Entry Flight Demonstration No. 1. The est involved the launch last May by a *Scout* booster of a non-radioactive model of a *SNAP-10A* reactor.

The payload containing the reactor was launched on an 800-mi. suborbital path from NASA's Wallops Station, Wallops Island, Va., to an impact point bout 250 mi. southeast of Bermuda.

The test provided experimental data o support theoretical analysis and laboratory studies of atmospheric re-entry phenomena. Telemetry was used to record the disassembly events and to measure the heating rates at critical points on the reactor until blackout of adio-frequency occurred—just before disassembly of the reactor.

The data on the temperature rises nd the times of the disassembly events ransmitted by the telemetry system were essentially as predicted. The telemetry system received temperature data from thermocouples, and disassembly information from movement switches on the payload. This information was then transmitted to several receiving stations where it was recorded on tapes.

- **Optics supplement telemetry**—In addition to the telemetry system, an optical data-acquisition system was used during the test. Optical instruments recorded the paths of the re-entry vehicle, the reactor and ejected fuel rods, and received signals from tracer material imbedded in the non-radioactive rods. The data obtained from the tracers will give information on the burn-up rate of the nuclear fuel under actual re-entry conditions.

Although the re-entry vehicle included a recovery system, the payload was not retrieved.

The test results are being evaluated by the Sandia Corp., Albuquerque, N.M., principal AEC contractor for aerospace nuclear safety, and by Atomics International, Canoga Park, Calif., the AEC's prime contractor for several space reactors, including *SNAP-10A*, and builder of the reactor mockup for the test.

The launch was carried out for the AEC by the National Aeronautics and Space Administration. The U.S. Weather Bureau, Air Force and Navy assisted extensively in the test.

- **'Fringe' data gathered**—In addition to obtaining data related to the aerodynamic effects on space reactors of atmospheric re-entry, RFD-1 provided other valuable results. The flight test was the first instance in which a *Scout* booster was flown on a non-zero gravity trajectory.

A new roll-stabilized gyro, weighing only eight pounds, was used effectively in conjunction with this test, as was a new type of meteorological rocket system for measuring atmospheric density above 200,000 ft. and winds above 300,000 ft.

Development of safety features of nuclear space devices is a major phase of the AEC's SNAP (Systems for Nuclear Auxiliary Power) program for the development of compact, lightweight, auxiliary power sources. The goal is design of devices to operate at desired power levels in space without presenting a radiation hazard to the Earth's population. ■

Army Assumes Management of ARPAT Radar

FINAL SYSTEMS TRACKING tests have been completed on the ARPAT measurements rader (AMRAD) designed to trace and analyze signatures of various experimental test targets during re-entry, and the system has been turned over to the U.S. Army Missile Command at White Sands Missile Range, N.M.

AMRAD is the measurements radar for ARPAT (Advanced Research Projects Agency Terminal), and is part of the Defense Department's Project Defender, one of a series of missile defense concepts.

It was designed, developed, installed and tested by Raytheon Co. under contract from the Army Missile Command, Redstone Arsenal, Ala., under ARPA sponsorship. The system is slated to be turned over to the Massachusetts Institute of Technology Lincoln Laboratory for operation by its field engineers and those of Raytheon.

The radar's prime mission is to obtain basic re-entry phenomena of ballistic missiles. Its 60-ft. antenna emits a pencil beam used to trace paths of payloads through test areas at re-entry speeds. The experimental tracker is designed to obtain a precision cross section and Doppler reentry measurement.

The high-power klystron transmitter is designed to develop 10-megawatt peak power. AMRAD also has provisions for an elaborate advance digital data processing system for recording the highly accurate data it gathers, according to Raytheon.

AMRAD's electronics system is housed in a 70 x 230-ft. building adjacent to the 95-ton pedestal.

DOD studying concept . . .

Proposed Fourth-Generation Polaris Would Use State-of-art Technology

Program-definition phase expected to be funded in FY '65 budget; missile would have highly-refined re-entry system

by Robert Lindsey

SUNNYVALE, CALIF.—A highly sophisticated, more accurate re-entry system, an increase of several inches in missile width, and weight reductions achieved with advanced materials and techniques will be features of the *B-3 Polaris* missile—if it is approved, (M/R, Nov. 4, p. 16).

However, state-of-the-art technology will be emphasized in the proposed fourth-generation Navy missile.

Company-funded studies by Lockheed Missiles & Space Co. have drawn a roughly defined concept for the *B-3*, but the Defense Dept. has yet to decide whether the system will be developed.

The Administration's upcoming Fiscal Year 1965 budget should reveal whether the program will be funded next year.

Although it seems highly likely that at least a program-definition phase for *B-3* will be recommended for FY '65, DOD is apparently uncertain as to how hard and how fast to push development.

It's rumored in the industry that contractors on the first three versions of *Polaris* may have to compete anew if there is a follow-on.

• **Do we need it?**—Apparently at the heart of the indecision about whether to proceed with a fourth-generation *Polaris* is uncertainty about future Soviet air and antisubmarine defenses.

In previous history of the *Polaris* program, range has been increased with each successive increment in energy; the interim *A-1* had a range of 1,200 mi., the *A-2* 1,500 mi., and the *A-3* 2,500 mi. Each carries a warhead variously estimated as equivalent to ½ to 1 megaton.

Range increase is not a primary goal of the *B-3*. With a substantial increase in the payload/range trade-off, the *B-3* could be given a range boost so that submarines would have greater sea room in which to operate; more importantly, it could provide space for penetration aids.

Although Lockheed and the Navy carefully decline any comments on this question, it seems obvious the principal rationale for *B-3* is to make space available for a highly advanced, multifaceted system of penetration.

Presumably the pace at which DOD pushes *B-3* will depend on intelligence estimates of Soviet antimissile capabilities. The *A-3*, like the *A-2*, is known to carry a family of decoys and active penetration aids; the question is, how long will they be adequate?

• **The philosophy**—Virtually all details of the proposed *B-3* are classified, and in fact the concept "is still pretty much in people's headbones," says Stanley Burriss, vice president and general manager of LMSC's missile systems division here.

But he revealed for MISSILES AN ROCKETS a few facets of the philosoph behind *B-3:*

In a seeming paradox, he said "*B-* would be about *A-3* state-of-the-art . but it would still be a 90% new bird.

"The *B-3* concept is, by DOD d rective, a minimized state-of-the-art im provement. We are taking what w learned subsequent to *A-3* and applyin it. We are studying every aspect, an unless there are improvements in exces of just a few percentage points they'r not worth changing, from an economi standpoint.

"At the time *A-1* was planned, ther was deliberately allowed a lot of growth and this has been realized with the *A-* and *A-3; B-3* is simply another part o the same growth curve."

Emphasizing that hardware woul be 90% new compared to *A-3*, he sai advances would be achieved "by a mor improved burning system, more efficien use of weights and more efficient use o space."

He implied that improved weight to-strength ratio materials, including ad vanced alloys and filament-wound cases would be used. Presumably, fluid-injec tion thrust-vector-control would be use on both stages rather than only on th second stage, as is the case with *A-3*

Another area of expected improve

ment is accuracy. Although accuracy of the *A-3* is regarded as excellent, Burriss said "we're never satisfied with accuracy; we think we can improve the accuracy in *B-3*."

Modification of the front end of the *A-3* to make possible a versatile warhead-re-entry system is a major part of the new program, But Burriss refused to answer questions on this point.

Asked why the follow-on would have a "B" designation rather than "A", he said "A implies a dimensional restraint which the B wouldn't have."

The implication is that *B-3* would, like *A-3*, be 31½ ft. long, but its diameter would exceed the 54-in. limitation of the first three models.

Rear Adm. Ignatius Gallantin, Special Projects Office director, has said that an axiom of the new program is that the missile could be launched from present *Polaris* submarines. Presumably, present submarines would have to be modified to permit installation of a wider launch tube.

One of the key advantages of the new Westinghouse Mark 21 *Polaris* launching system (M/R, Dec. 2, p. 27) is that it is modular; by refitting, a larger launch tube can be installed in the submarine as a package. But it would be necessary to either develop a better shock-absorbtion system or trade off shock mitigation for the added space. Another avenue of growth is removal of spacers around the missiles within the present tube; this might realize about two inches of growth for the missile.

If it is developed, Burriss estimated, *B-3* would cost on the same order as the *A-3*, whose developmental cost has never been revealed.

- **Economic factors**—The *B-3* decision is important to Lockheed's future, and, of course, that of other contractors on the FBM program. LMSC faces a tail-off in the *Polaris* R&D effort this spring as the *A-3* nears the end of its developmental cycle.

To maintain its present level of activity and employment, it must either begin work on a follow-on or find new business.

From a production standpoint, business seems assured for sometime. LMSC holds contracts for a low rate of *A-2* production for several years, and manufacture of *A-3's* will be big money item well into 1967. Sweetening the pot are expected sales to Britain and, perhaps, the NATO multi-lateral force.

Preparing for a possible contract-depression "bathtub" between tail-off of the *A-3* and—assuming it comes—phase-in of *B-3*, LMSC is pushing hard now on a variety of company-funded concepts for ocean-based weapon systems and new ballistic missile designs, including tactical ballistic weapons, Burriss said.

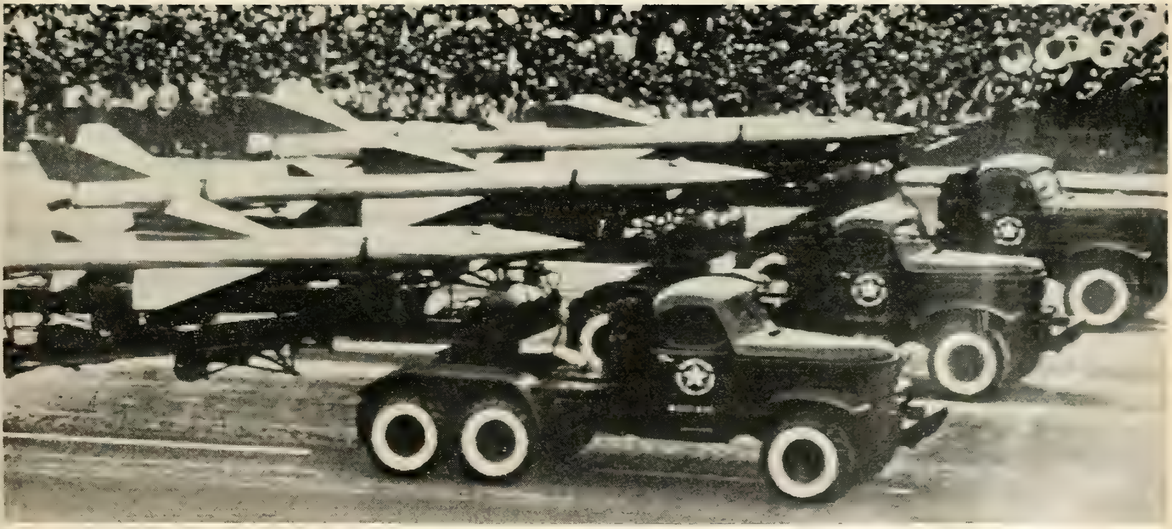
He noted that development of *A-3*, which now has some 30 flight tests under its belt, is proceeding on schedule. Production of the *A-3* will begin in two or three months, and deployment of the new missile is scheduled in August.

Burriss said about 10 more developmental flight tests are planned in the program to garner experience and confidence in repeatability of the system, but the design has long been frozen.

Burriss said he personally feels it is important to make a decision soon on the follow-on. He cited a study by Harvard University, the "Weapons Systems Acquisition Process," which he said plots an optimum curve for phase-in of one program and phase-out of a predecessor.

As a function of approximately 12 factors, such as fixed costs, overhead, and manpower, he said the curve fixes the optimum point for the new program to begin. "We hit it right on the nose, incidentally, on *A-3*."

"If you wait too long, the cost can rise substantially. I'm afraid we're going to wait too long on *B-3* and miss it." ■



Cuba Flexes Its Missile Muscles On Revolution Anniversary

FEATURED AT a recent Havana parade were these missiles, identified by Pentagon officials as surface-to-air defense systems. The missiles were part of a parade that passed through the city's Revolution Plaza on the occasion of the fifth anniversary of Castro's Cuban revolution. Under terms of the late President Kennedy's negotiations with the Soviet Union during the October, 1962, Cuban crisis, defensive missiles were allowed to remain in the country.

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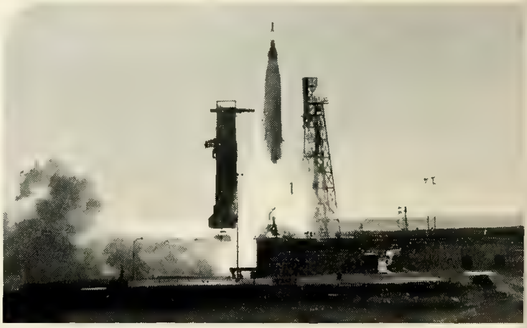

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Current status of U. S. missile and space programs

Missiles

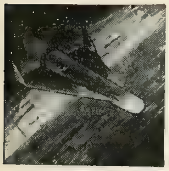
PROJECT	CONTRACTORS	DESCRIPTION	STATUS
ALFA (Navy)	Navy, prime	ASW surface-to-underwater; weight—500 lbs.; solid; HE depth charge; free-flight rocket; range 900 yds.	Operational; deployed on destroyers and cruisers
ASROC (Navy)	Minneapolis-Honeywell, prime; Sangamo Electric, sonar; torpedo, GE; Librascope-General Precision, fire control	ASW surface-to-underwater; solid; nuclear or conventional warhead, range between 1800 yds. and 8 miles; weight: 1000 lbs.; unguided	Operational on DE, DD, DLG, & heavy cruisers. Advanced ASROC being developed; one "live" weapon fired in Pacific nuclear tests
ASTOR (Navy)	Westinghouse, prime	Mark 45 ASW underwater to underwater wire-guided torpedo; nuclear or conventional; range, about 11 n. m.; electric	In production; to be deployed on hunter-killer submarines
ATLAS (Air Force)	STL, systems engineering & technical direction; GD/Astronautics, frame; GE/Burroughs/Arma, guidance; Rocketdyne, propulsion; GE/Avco, re-entry vehicle	ICBM; 5500-to-9000 mile range; liquid; nuclear; ATLAS "E" and "F" series inertial guidance; ATLAS "D" radio inertial	13 squadrons operational at 11 bases; total no. of missiles: 129; phaseout to begin soon; ATLAS Standard Launch Vehicle being developed for AF space programs; 5-engine model proposed
BOMARC (Air Force)	Boeing, prime; IBM/Westinghouse, guidance; Aerojet/Marquardt, propulsion	Ramjet surface-to-air interceptor; liquid booster; 200 n. m. range; Mach 2.5; nuclear; ceiling, over 68,000	Five bases operational in northeastern U.S.; production completed; costs $20 million per year to operate system
BOMARC B (Air Force)	Boeing, prime; Gen. Precision Aerospace/Westinghouse, IBM guidance; Thiokol/Marquardt, propulsion	Ramjet, surface-to-air; solid booster; Mach 2.7; more than 400 n. m. range; nuclear	First base operational May, 1961; two more planned; production completed
BULLPUP (Navy-Air Force)	Martin, prime; Martin, guidance; Thiokol/Naval Propellant Plant, propulsion; Maxson, second-source prime, electronics.	Air-to-surface; 3-6 mile range; radio-link command guidance (visual reference); conventional 250-1000-lb. bomb; BULLPUP B: nuclear warhead and one pre-packaged liquid motor; nuclear-tipped	Deployed with Atlantic and Pacific Fleets; operational with Air Force units; new training version under development, as TGAM-83 replacement
CORPORAL (Army)	Firestone, prime; Gilfillan Bros., Inc., guidance; Ryan, propulsion	Surface-to-surface; 75 n. m. range; liquid; nuclear; pre-set & command guidance	Deployed in Europe. SERGEANT replacing CORPORAL
DAVY CROCKETT M-388 (Army)	In-house project directed by Army Weapons Command at Rock Island, Ill.	Surface to surface; solid; bazooka-launched; sub-kiloton nuclear warhead; two launchers: vehicle-mounted or carried by two men	Operational in Europe; $13 million provided in FY '64 budget; 3 per ROAD battalion; seen as defensive rather than offensive weapon to prevent overrun of Europe
ENTAC (Army)	Nord Aviation, prime	Antitank; 6600-ft. range; 37 lbs.; solid; shaped charge HE warhead; wire-guided; man-portable	Operational; Army buying from French in quantity to replace SS-10
AADS-70 (Army)	Hughes, Raytheon, RCA—feasibility studies	Field army ballistic missile defense system, mobile	Expected to be operational in 1970's
FALCON (Air Force)	Hughes, prime; Hughes, guidance; Thiokol, propulsion; Lockheed Propulsion, AIM-47 propulsion	Air-to-air; 5 n. mi. range; supersonic; solid; conventional; AIM-4A, and 4E, active radar homing guidance; AIM-4B, 4-C, 4-D, and 4-F, IR homing; AIM-26 model has nuclear warhead and hybrid IR radar homing	Operational; buy-out of 4E, 4F and 26 in FY '62; AIM-47 under minimum effort development
GENIE (Air Force)	Douglas, prime; Aerojet-General, propulsion	Air-to-air; unguided; 6-mile range; nuclear; solid rocket; supersonic; proximity fuzing	Operational on F-101B & F-106; improved version cancelled
HAWK (Army)	Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion	Surface-to-air; 22-mile range; 100-45,000 ft. ceiling; launch wt., 1275 lbs.; solid; conventional; provides defense against medium and low-flying aircraft and cruise-type missiles	Operational; deployed in Europe, Panama, Okinawa, U.S. (13 battalions); bought by Sweden and Israel; advanced HAWK being funded at $25.9 million for R&D as antimissile weapon. NATO producing

★ Indicates changes since November, 1963, Astrolog

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
HONEST JOHN M-31, M-50 (Army)	Douglas/Emerson Electric, prime; Hercules, propulsion	Surface-to-surface; unguided; M-31 12-mile range; M-50, 20-mile range; nuclear; 5900 lbs.; M-50 being deployed	Operational; deployed in Europe; to be replaced by LANCE
HOUND DOG (Air Force)	North American, prime; Autonetics, guidance; Pratt and Whitney, propulsion	Air breathing air-to-surface standoff missile; about 600 n.-mi. range; Mach 2+; turbojet nuclear B version in production, ceiling in excess of 50,000 ft.	Operational; to be launched from B-52G intercontinental bombers; stockpile expected to exceed 400 to compensate for SKYBOLT cancellation
JUPITER (Air Force)	Chrysler, prime; Sperry Farragut, guidance; Rocketdyne, propulsion; Goodyear/CTL, re-entry vehicle	IRBM; liquid; nuclear; range over 1500 mi.; guidance; all-inertial	Being withdrawn from operation; replaced by POLARIS; future of missiles being studied
★LACROSSE (Army)	Martin, prime; Martin/Federal Div. ITT, guidance; Thiokol, propulsion	Surface-to-surface; mobile; command guidance; 20-mile range; solid; nuclear	Being phased out of inventory.
LANCE (Army) (Formerly designated MISSILE B)	Chance Vought Div., Ling-Temco-Vought, prime; Systron-Donner, AUTOMET guidance	A highly mobile general-purpose missile; range 3-30 miles; Automet guidance; one missile per launcher; nuclear and conventional warhead; pre-packaged storable propellants	Large-scale development; eventually will replace HONEST JOHN and LACROSSE; division support weapon; to use multi-system test equipment
LITTLE JOHN (Army)	Emerson Electric, prime; Hercules Powder, propulsion	Surface-to-surface unguided; 10-mile range; solid; nuclear; supplements medium and heavy artillery in airborne divisions and air-transportable commands	Two battalions activated in '61; each equipped with four launchers; air and helicopter transportable; may be replaced by LANCE
LOW ALTITUDE SUPERSONIC VEHICLE (Air Force)	Ling-Temco-Vought, nuclear vehicle components; AEC/Marquardt, nuclear and chemical technology	Surface-to-surface; low-altitude; supersonic; nuclear ramjet; designed to conduct long aerial patrols at speeds up to 2000 mph	Propulsion system being developed under project PLUTO; feasibility proven by TORY reactor tests. Feasibility tests in 1964
M72 (Army)	Hesse-Eastern Div., Flightex Fabrics, prime	Light antitank rocket; carrier tube launcher; 4.5 lbs.; range 500 yd.; earlier called LAW	Operational
MACE (Air Force)	Martin, prime; Goodyear/AC Spark Plug, guidance; Thiokol/Allison, propulsion	Air-breathing surface-to-surface; more than 650-mile range; turbojet and solid; nuclear; B model: 1200-mile range; inertial guidance	Five MACE-A and one MACE-B squadron deployed in Europe; two MACE-B squadrons on Okinawa in hard sites
MATADOR (Air Force)	Martin, prime; Air Force, guidance; Thiokol/Allison, propulsion	Air-breathing surface-to-surface; 500 mile range; speed, about 650 mph; ceiling above 35,000 ft.	Being turned over to West Germans; also deployed in Korea and on Taiwan
★MAULER (Army)	GD/Pomona, prime; Hughes, guidance; Lockheed, propulsion; deHavilland, IR acquisition; Raytheon, radar; Burroughs, computer; FMC, vehicle	Surface-to-air; IR acquisition; solid; weight, 120 lbs.; highly mobile antiaircraft and antimissile missile; tracked vehicle; 9 per launcher rack	Development; suffering serious guidance problems. Army studying to decide whether to continue.
★MOBILE MEDIUM-RANGE BALLISTIC MISSILE (Air Force)	Development Phase: Hughes, integration, assembly and checkout; Ford Aeronutronic re-entry system; Thiokol, propulsion; Goodyear Aerospace Corp., transporter-launcher-erector; Martin-Marietta, command and control; General Precision, guidance	Two-stage, solid propellant, stellar-inertial guidance; entire system contained in one mobile vehicle; range: 300-1500 miles	Continued development of guidance, control systems; contractor team realigned for development under $73.1 million FY 1964 appropriation. In programming prior to Phase II.
MINUTEMAN (Air Force)	STL, systems engineering and technical direction; Boeing, major contractor; Autonetics, guidance; Thiokol, propulsion first stage; Aerojet, propulsion second stage; Hercules third stage; Avco, re-entry vehicle	2nd-generation ICBM; solid; deployed in hardened and dispersed silos; 32 sec. reaction time; nuclear; 3 stages; range: over 5000 miles; guidance, all-inertial; target selected in seconds; advanced MINUTEMAN with greater range-payload and new re-entry vehicle under development	Development; 150 now operational at Malmstrom, Mont.; later at Ellsworth, S. D.; Whiteman, Mo.; Minot, N. D., Grand Forks, N. D.; 950 missiles through FY '64; eventual force size may be 1300; advanced version to be fired from airborne command posts; expected operational 1965-66
NIKE-HERCULES (Army)	Western Electric, prime; Western Electric, guidance; Hercules and Thiokol, propulsion; Douglas, airframe	Surface-to-air; 75-mile range; ceiling, in excess of 150,000 ft.; solid; command guidance; Mach 3+; nuclear or conventional; antiaircraft, tactical missiles; weight, 10,000 lbs.	Over 80 batteries deployed in U.S.; over 10 N-H batteries deployed overseas. Being equipped with HIPAR, a high power acquisition radar, and anti-tactical-ballistic-missile capabilities
★NIKE-ZEUS (Army)	Western Electric, prime; Bell Telephone, guidance; Thiokol/Lockheed, propulsion; Douglas, airframe	Antimissile missile; 3-stage; 200-mile range; solid; nuclear; command guidance; weight, 22,800 lbs.; length, 48 ft.; diameter, 36 in.; fin span, 10 ft.	Downgraded in favor of NIKE-X; continued development planned; funded for $89 million in FY '64; ten successful intercepts. White sands tests completed.
NIKE-X (Army)	Western Electric, prime; Bell Telephone, guidance; Thiokol, ZEUS propulsion; Douglas, ZEUS airframe; Martin-Marietta, SPRINT missile prime; Hercules Powder Co., and Lockheed Propulsion Co., SPRINT propulsion	Most advanced portion of NIKE-ZEUS concept; uses a mix of ZEUS/SPRINT missiles and multi-function array radar (MAR)	Engineering development; funded for $246 million on accelerated development schedule, but deployment still deferred; more effective than NIKE-ZEUS
★PERSHING (Army)	Martin, prime; Bendix, guidance; Thiokol, propulsion	Surface-to-surface; two-stage solid; inertial guidance; approx. 400 n. mile range; nuclear; transported on FMC XM474 tracked vehicle; to replace REDSTONE	Flight test program completed. Troops training in Ft. Wingate (N.M.)—White Sands shots. West Germany buying two battalions.

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
PHOENIX (Navy)	Hughes Aircraft Co.; Rocketdyne, propulsion	Air-to-air missile for use with the TFX fighter aircraft	Development; HAC has $12.2-million contract
★**POLARIS** (Navy)	Lockheed, prime; GE/MIT/Hughes, Minneapolis-Honeywell, Raytheon, guidance and fire control; Aerojet-General, Hercules, propulsion; Lockheed, re-entry vehicle; Nortronics, checkout; Autonetics/Sperry, SINS; Westinghouse, launching equipment: Vitro, systems engineering coordination and training; Systron-Donner, ignition programing	Underwater and surface-to-surface; solid; 1200-n.-mi. range; A-1 aboard first 10 submarines; nuclear; A-2 (1500 n.-mi.) aboard submarines 6-18; A-3 (2500 n.-mi.) aboard 19th and subsequent subs; all subs to get A-3 eventually; Total authorized POLARIS submarine program: 41	Nine subs each with 16 missiles operational; A-2 operational; A-3 in 1964; 27 A-3 flight tests have been conducted; 17 fully successful; deployed in Atlantic and Mediterranean; Pacific servicing facilities being built; British to buy A-3 missiles from U.S. First A-3 submarine firings successful
QUAIL (Air Force)	McDonnell, prime; Guidance Technology, Inc., guidance; GE, propulsion; Thompson Ramo Wooldridge, ECM equipment	ECM-carrying decoy; about 200 m. range; turbojet powered advanced version with 400 mile range has been flight tested	Deployed at SAC bases; carried by B-52; procurement completed FY '61
★**REDEYE** (Army)	GD/Pomona, prime; Hughes, IR seeker; Atlantic Research, propulsion	Surface-to-air; 4-foot, 22-lb. bazooka-type; IR homing guidance; solid; conventional; length, 44 in.; diameter, 2.75 in.	Development; problems largely solved after two-year slippage.
REDSTONE (Army)	Chrysler, prime; Sperry Farragut, guidance; Rocketdyne, propulsion	Surface-to-surface; liquid; 200-mile range; inertial guidance; nuclear	Deployed in Europe; being replaced by PERSHING
REGULUS I SSM-N-8 (Navy)	Ling-Temco-Vought, prime; Sperry, guidance; Allison, propulsion	Surface-to-surface; turbojet and solid; 500-n.-mi. range; speed, about 600 mph; ceiling, approx. 40,000 ft.; nuclear	Deployed aboard 2 cruisers; phaseout of 5 REGULUS subs started last year; KDU-1: drone version; missiles retrofitted with airborne guidance
SERGEANT (Army)	Sperry Utah, prime; Sperry, guidance; Thiokol, propulsion	Surface-to-surface; solid; over 75 n. mi. range; nuclear; inertial guidance uses drag brakes; 10,000 lbs.	Production; major procurement to be completed during FY '63; replacing CORPORAL; West Germany buying and has activated one battalion
SHILLELAGH (Army)	Ford Aeronutronic, prime; Picatinny Arsenal/Amoco Chemicals Corp., propulsion; Aeronutronic, guidance	Surface-to-surface; lightweight; vehicle-mounted for use against field fortifications, armor and close-in support of troops	Development; testing at White Sands; to use multi-system test equipment; engineering development stage begins in FY '64; to be installed on Gen. Sheridan assault vehicle
SHRIKE (Navy)	NOTS-China Lake, prime; Texas Instruments, guidance; Rocketdyne, propulsion	Air-to-surface; anti-radar; guidance, passive radar homing; solid motor; formerly ARM	Development; first production buy in FY '63; AF plans to buy it during FY '64
★**SIDEWINDER** (Navy-Air Force)	GE-Philco, prime; Philco/GE, guidance; Naval Propellant Plant/Naval Ammunition Depot, McAllister and Rocketdyne, propulsion	Air-to-air; IR guidance; more than 2 m. range; conventional; 1-C models: switchable IR and radar-guided warheads; improved rocket motor	Deployed with Navy and Air Force; all-weather type under development; delivery of 1-C version started in 1962; NATO-built version now in production
SPARROW III AAM-N-6A (Navy)	Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion	Air-to-air 5-8 mile range; Mach 2.5-3; ceiling, over 50,000 ft.; semi-active, CW homing, guidance; solid; conventional	Operational with carrier aircraft; production begun on advanced version (SPARROW III B) prime armament for F4H-1 and F3H-2 interceptor; SPARROW III and III A in use; production begun on advanced version as prime armament for F4B and F4C interceptors
SPRINT (Army)	Martin-Orlando, prime; Hercules Powder and Lockheed Propulsion Co., propulsion; Bell Telephone Laboratories, guidance	High-acceleration missile for low-altitude interception of ballistic missiles; to be part of the missile mix in a NIKE-X battery	Development
★**SUBROC** (Navy)	Goodyear, prime; Gen. Precision/Aerospace, guidance; Thiokol, propulsion; Librascope-General Precision, fire control	Underwater-air-underwater antisubmarine missile-depth bomb; 25-30 mile range; solid; nuclear	Production; scheduled for installation in Thresher class subs; will be operational this year
SS-10 (Army)	Nord Aviation, prime; GE, U.S. licensee	Surface-to-surface; primarily antitank; 1600-yards range; 33 lbs solid; wire guided; conventional	Operational with U.S., French and other NATO and Western units; battle-tested in North Africa; U.S. replacing with ENTAC
SS-11 (Army)	Nord Aviation, prime	Surface-to-surface; antitank; also helicopter-to-surface; 3800-yard range; 63 lbs; wire guided; conventional	Operational, to be used with airborne units and Army helicopters
TALOS (Navy)	Vitro, systems engineering; Bendix, prime; Bendix, McDonnell, Allegany Ballistics Lab., propulsion; Sperry, guidance; GE, launching gear	Ship-to-air; 65-mile range; solid and ramjet; Mach 2.5; nuclear; radar beam riding/semi-active homing guidance	Operational aboard cruisers Galveston, Oklahoma City and three heavy cruisers; Long Beach, nuclear-powered cruiser, has advanced TALOS
TARTAR (Navy)	Vitro, systems engineering; GD/Pomona, prime; Raytheon, guidance; Aerojet-General, propulsion; Northern Ordnance, launching gear	Ship-to-air; 10-mile range; Mach 2; beam-riding guidance; solid dual-thrust motor; conventional	Operational; installed aboard 15 guided missile destroyers and cruisers equipped with TALOS
TERNE (Navy)	Kongsberg Vapenfabrikk, prime; Arma, systems integration	Surface-to-underwater ASW missile; 264 lbs; HE warhead	Navy buying from Norway to equip two destroyer escorts
TERRIER/ADVANCED TERRIER (Navy)	Vitro, systems engineering; GD/Pomona, prime; GD/Pomona guidance section; Sperry, radar; ABL, propulsion; Northern Ordnance, launching gear	Ship-to-air; 10-mile range; Mach 2.5; 27 feet long; solid; conventional; 2 advanced versions operational	Operational aboard two attack carriers, 6 cruisers, and 12 missile frigates

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
THOR (Air Force)	Douglas, prime; AC Spark Plug, guidance; Rocketdyne, propulsion; GE, re-entry vehicle; Thiokol, solid rockets for added thrust	Surface-to-surface IRBM; 1500-mile range; liquid; nuclear; guidance, all-inertial; used extensively as space booster	Phaseout; 15 missiles to be converted Douglas for space boosters; some vehicl "souped up" by adding solid rockets f DISCOVERER program
TITAN I (Air Force)	STL, systems engineering & technical direction; Martin, prime; Bell/Sperry, guidance; Aerojet-General, propulsion; Avco, re-entry vehicle	ICBM; 5000-mile range, LOX/RP-1 fueled; 90 ft. long; 2 stages	Operational; 54 missiles at 5 bases
TITAN II (Air Force)	STL, system engineering and technical direction; Martin, prime; AC Spark Plug, guidance; Aerojet-General, propulsion; GE, re-entry vehicle	ICBM; over 5000-mile range; N_2O_4 & Aerozine-50 storable fuels; 115 ft. long; 2 stages; greatest payload & range of any U.S. ICBM; basic core vehicle for TITAN III	One squadron operational at Davis-Montha AFB; some trouble experienced with secon stage and with vibration in GEMINI booste version; overall performance high
TOW (Army)	Hughes, prime	Tube-launched, optically tracked, wire guided, HE warhead	Follow-on to ENTAC
★**TYPHON** (Navy)	Bendix, GD/Pomona, missile and missile electronics; Westinghouse, weapons direction system and radar; McDonnell/Allegany Ballistics Laboratory, propulsion; Northern Ordnance, launching gear	Medium and long range seagoing antiaircraft and antimissile missiles with offensive capability against surface ships and shore targets	Development; successor for TALOS, TARTA and TERRIER. System is encountering de velopment problems, under intensiv DDR&E re-study
WALLEYE (Navy)	NOTS-China Lake	Air-to-surface 1000-lb. glide bomb with homing guidance, no propulsion; powerful conventional warhead	Development; Navy says it will be th "most accurate and effective air-to-surfac conventional weapon ever develope anywhere."
ZUNI (Navy)	Naval Ordnance Test Station, prime; Hunter-Douglas, propulsion	5-inch, air-to-surface; solid; unguided; 5 n.-mi. range; conventional	Operational; designed for use on je fighter and attack aircraft



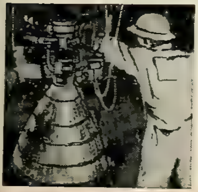
Satellites and Spacecraft

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
ANNA (NASA)	Bureau of Naval Weapons/Applied Physics Lab, prime; AF Cambridge Research Laboratories/Edgerton, Germeshausen & Grier flash tube experiment; Army Engineers/Cubic Corp., CW transmitter	Geodetic satellite; 600-mi. orbit; 36-in. aluminum sphere (with solar cell belt, 48 in.); weighs 355 lbs.; boosted by DELTA	Development; first launch failed May 10; second launch successful in November. Program now under NASA management. NASA to launch one satellite per year beginning in 1964
★**APOLLO** (NASA)	North American, Command & Mission Modules, systems integration; Grumman Lunar Excursion Module (LEM); MIT, guidance development; Collins Radio, telecommunications; Minneapolis-Honeywell, stabilization & control; AiResearch, environmental control; Northrop Ventura, parachute recovery; Lockheed Propulsion Co., escape tower rocket; Marquardt, reaction controls; IBM, realtime computer complex; Westinghouse, power conversion equipment	Three-man spacecraft for Earth-orbital, lunar-orbital and lunar-landing missions. Boosters: SATURN I and SATURN IB for Earth orbits; SATURN V for lunar rendezvous; 3-modular spacecraft: command module, 5 tons; service module, 23 tons; lunar excursion vehicle, 15 tons; total weight: 85,000 lbs.	Unmanned Earth oribtal shots scheduled 1964-65; lunar orbits 1968; lunar landing by 1970; first manned orbital flight fourth quarter 1966
ARENTS (ARPA)	GD/Astronautics, prime	Series of three satellites to investigate space environment of 22,000 mi. and to test long-term behavior of components at this altitude; ATLAS-CENTAUR booster	Contract let to build three payloads; launchings aboard a NASA payload; program re-evaluated due to CENTAUR delay
AEROSPACE PLANE (AF-NASA)	No contracts announced	Manned, hypersonic spacecraft capable of Earth-to-orbit-and-return; turbofan, Mach 0-3; ramjet, Mach 3-8 or 10 (oxygen collected and liquefied during this cycle); Mach 8-10 orbital speeds, LH_2-LOX rocket	Joint NASA-AF research program approved. NASA funding $4 million in FY '64
★**ASSET** (Air Force)	McDonnell Aircraft Corp., prime; Minneapolis-Honeywell, guidance	Aerothermodynamic/elastic Structural Systems Environmental Tests for various materials combinations during re-entry; two versions planned, 1100 lbs. (4) and 1200 lbs. (2). Strongly resembles X-20. Length: 68.7 in.; span: 58.9 in.	Development; program under sharp expansion as partial substitute for cancelled X-20. One AMR shot successful
BAMBI (ARPA)	Studies: GD/Astronautics, STL	Satellite system capable of intercepting enemy missiles in boost using space based platforms and interceptors	Feasibility still not proved; additional research under way
BIOS (NASA)	GE, prime	1,000-lb. recoverable capsules with primates aboard; capable of orbital flights up to 30 days. Flights to begin 1965. Will be launched by THRUST-AUGMENTED DELTA	Six flight models to be built. First flight in 1965. Others to follow at three-month intervals

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
★**MEDIUM ALTITUDE COMMUNICATIONS SATELLITE** (AF-DCA-Army)	Philco-TRW-STL working under study contract extension.	Multiple-launch, active repeater ComSat; 24-30 satellites in 5000-12,000 naut. mile orbits; weight, less than 150 lbs.; ATLAS-AGENA booster	One of two systems resulting from reoriented ADVENT program; initial operational capability planned for 1964, fully operational by 1966
COMMUNICATION SATELLITE PROGRAM, HIGH-ALTITUDE (AF-DCA-Army)	ITT, systems engineering & technical direction for DCA	24-hour, station-keeping, active repeater ComSat; operational system, 3-10 satellites; weight, 500 lbs.; wide bandwidth communications equipment for encryption and anti-jamming; booster, ATLAS-AGENA	Second system evolved from ADVENT; initial capability, 1964; operational, 1966
DISCOVERER (Air Force)	Lockheed, prime; GE, re-entry vehicle	THOR-AGENA and ATLAS-AGENA launchings of stabilized satellites; main purpose is to test techniques and components for military space systems	Program life extended; all data on launchings classified as part of new DOD information policy; testing of AGENA D assigned to DISCOVERER program
★**ECHO** (NASA)	Langley Research Center, prime	ECHO I: 135 ft. inflatable sphere in 700- to 805-mile orbit; passive communication satellite. THOR for ballistic tests; THOR-AGENA for orbital	ECHO I in orbit since Aug. 12, 1960; two ballistic shots in 1962 unsuccessful. Orbital launch from PMR planned first quarter 1964
GEMINI (NASA)	McDonnell, prime; Rocketdyne, spacecraft propulsion; General Electric, fuel cell; IBM, guidance system integration and computer; Minneapolis-Honeywell, guidance; Westinghouse, rendezvous radar; AiResearch, environment	Bigger and heavier MERCURY capsule; to carry two men for periods up to two weeks, TITAN II to be used as booster. ATLAS-launched AGENA will be used for rendezvous missions. 15 spacecraft will be produced	Development; will be used to determine feasibility of rendezvous for lunar mission; first unmanned flight, early 1964. Manned and rendezvous flights, 1964-65; AF participation in program has been approved; this could add 4 to 6 more spacecraft to the program
★**INTERPLANETARY MONITORING PLATFORM** (NASA)	Goddard Space Flight Center, prime; Martin Co. developing nuclear power unit	125-lb. satellite launched into deep-space orbit with an apogee of 172,000 miles. It will measure radiation and solar flares in advance of Project APOLLO hazard. Launched by DELTA booster from AMR	Program calls for eight satellites. Launches will begin early 1964. Later flights will use a nuclear power unit as replacement for solar cells
★**LUNAR ORBITER PHOTO CRAFT** (NASA)	Boeing, prime; RCA, power and communications; Eastman Kodak, cameras.	800-lb. spacecraft launched by ATLAS-AGENA will orbit Moon taking pictures of lunar surface	Five flights scheduled beginning in 1966
LUNAR LOGISTICS VEHICLE (NASA)	None	Spacecraft to carry support payloads to the Moon. Two designs under study, LEM Truck and logistics spacecraft with 25,000-to-30,000-lb. payload	Program decision expected 1964. No funding expected until FY '66; program would cost about $1 billion
★**MANNED ORBITING LAB** (AF)	Two or three study contract awards due soon	Two-man spacecraft to establish military usefulness of man in space; TITAN III; GEMINI X capsule atop 10-by-20 ft. canister lab; total weight about 25,000 lbs.; orbit below 350 mi.	R&D. Unmanned GEMINI launch early 1966, manned late; unmanned canister launch late 1967, manned first half 1968. Rendezvous capability possible later
★**MANNED ORBITING SPACE STATION**	Under study	Manned space station for testing components and techniques in the space environment. Design under study by NASA and AF	Decision not expected for several years
MARINER (NASA)	JPL, prime	550-lb. unmanned spacecraft for early interplanetary missions to vicinity of Mars and Venus; boosted by ATLAS-AGENA B; 1000-lb. MARINER B also under development	Twelve shots planned. First scheduled Venus fly-by August, 1962, unsuccessful after booster failure; second passed within 21,594 mi. of Venus Dec. 14; two Mars fly-by missions planned in late 1964
MDS (NASA)	Fairchild Stratos, prime	3400-lb. meteoroid detection satellite employing two 50 x 15 ft. extendable detector wings; Earth orbit, 300 to 800 miles; booster SATURN 1	Development; will measure size, energy and frequency of meteoroids to evaluate hazards of impact with manned spacecraft; first launch scheduled for third quarter. Two will be orbited
MERCURY (NASA)	McDonnell, capsule	First U.S. manned satellite; 4000 lbs. + (capsule including escape rocket); boosters: ATLAS and REDSTONE	First manned orbital flight Feb. 20, 1962, by Lt. Col. John Glenn, USMC. 2nd, Cmdr. Scott Carpenter, May, 1962; six-orbit flight by Walter Schirra, Oct. 3, 1962; modified MERCURY made 22-orbit flight with L. Gordon Cooper on May 15. Program now completed
MIDAS, PROGRAM 239A (Air Force)	Lockheed, prime; Aerojet, IR detector system	Early-warning satellite; detect ICBM launchings by IR; R&D models weigh 2.5 tons; plans being finalized for early integration of advanced payloads	Development; re-oriented system now funded for total of $450 million; funding of $150 million for FY '63 now cut to $100 million for FY '64

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
NIMBUS (NASA)	Goddard Space Flight Center, prime; GE, integration and testing; RCA, videcon cameras	2nd-generation weather satellite; Earth-stabilized polar orbiting; 750 lbs.; TV cameras and IR scanners in payload; THOR-AGENA B booster	First launching scheduled for early 1964; second, six months later; two R&D satellites
OAO (NASA)	Grumman, prime; Westinghouse, electronic components; GE, stabilization and control; Kollsman, star trackers; IBM, data processor and storage	3500-lb. orbiting astronomical satellite observatory equipped with 36-in. primary mirror, spectrometer; booster, ATLAS-AGENA D	Three flights beginning in 1965
★**OGO** (NASA)	Space Technology Laboratories, prime	1000-lb. satellites with instruments for geophysical measurements; polar (POGO) and eccentric (EGO) shots planned; can carry 50 experiments; ATLAS-AGENA B, THOR-AGENA D, CENTAUR boosters	First flight scheduled in 1964; 19 experiments planned for first shot; five other flights planned
★**OSO** (NASA)	Ball Brothers, prime	440-lb. orbiting solar observatory; DELTA and ATLAS-AGENA boosters, S-16 early version; S-17 and S-57 advanced versions	First flight March 7, 1962, highly successful; first flight for S-17 planned for first quarter 1964; five more flights planned; advanced OSO to be built by Republic
PIONEER (NASA)	STL	120-lb. spin-stabilized solar probe; DELTA launch vehicle; cylindrical; covered with 10,000 solar cells; 4 outrigger booms for stabilization; 5 experiments, 60-to-90-million-mi. communication capability	Seven launches in program; early 1965 launch schedule set; orbits range from .8 to 1.2 au for 6-mo. lifetime
★**RANGER** (NASA)	JPL, prime; Aeronutronic, capsule; Hercules, retrorocket; Northrop, support contractor	300-lb. instrument capsule with seismometer rough landed on Moon; before impact, TV camera takes pictures of lunar surface; ATLAS-AGENA B booster	R&D RANGER VI launch postponed; program undergoing management change; total of nine spacecraft planned; next launch, first quarter 1964
★**RELAY** (NASA)	STL, project coordination and systems planning; RCA, prime	172-lb., spin-stabilized, wide-band, 700-4000-mile orbit active repeater experimental communications satellite. DELTA booster	Britain, France, Brazil and Germany building ground stations; first launch, Dec. 13, 1962; RELAY II first quarter 1964
SATELLITE INSPECTOR (SAINT) PROGRAM 706 (Air Force)	RCA, prime; Hughes, detection equipment	Anti-satellite inspection system also capable of destroying hostile vehicles	R&D; re-oriented; 3 study contracts to be awarded to determine characteristics of a SAINT vehicle, based on a manned system using GEMINI capsule
SAMOS (Air Force)	Lockheed, prime; photo intelligence equipment, Eastman Kodak; capsules, GE; parachute and guidance recovery equipment, Avco & Northrop Ventura	Reconnaissance satellite; formerly SENTRY; R&D model weighs 4100 lbs. with E-5 capsule (3000 with E-6); ATLAS-AGENA booster; 100-300-mile circular polar orbit	Operational; advanced SAMOS under development; FERRET version used for electronic intelligence and communications eavesdropping
★**SERT** (NASA)	RCA, prime	Spinning satellite carrying two electric-propulsion engines for environmental tests	Two and possibly three flights planned. First, third quarter, 1964
★**SURVEYOR** (NASA)	Hughes, prime; Martin, SNAP device	2100-lb. spacecraft for soft-landing 100-300 lb. instruments on Moon; ATLAS-CENTAUR booster; SNAP nuclear generator optional	First Moon flights early 1965; seven soft-landing vehicles planned
SYNCOM (NASA)	Hughes, prime	24-hr. orbit instantaneous narrow band, active repeater communications satellite. DELTA booster; 28 inches in dia. and will weigh about 55 lbs.; capable of accommodating one full duplex radio telephone channel	First launch failed, Feb. 14, 1963; satellite believed to be in orbit but contact lost. SYNCOM II launched July 26, 1963, completely successful. 500-lb. advanced SYNCOM to be developed
★**SMS** (Synchronous Meteorological Satellite) (NASA)	Republic, Astro-Electronics of RCA, Hughes, study contracts	24-hour weather satellite, Earth-stabilized; TV cameras with variable focus; may use SNAP-50 for power; booster may be ATLAS-AGENA or CENTAUR	Launch schedule under study; funding may be in FY '65 budget
TELSTAR (AT&T-NASA)	BTL, management for AT&T	170-lb., active repeater, experimental industry communication satellite; DELTA booster	Development; first launch July 10, 1962, highly successful; second launch May 7, 1963, also successful
★**TIROS** (NASA-Wea. Bu.)	RCA, prime	285-lb. meteorological satellite; TV pictures of cloud cover; IR sensors to gather heat balance data; one TIROS to be tested for effectiveness in highly elliptical orbit (3000-mi. apogee)	R&D; eight satellites launched; all successful. Next launch summer, 1964. Seven more added to program (4 R&D NASA, 3 operational, Weather Bureau)
TRANSIT (Navy)	Applied Physics Laboratory, prime; Martin, SNAP device; Westinghouse, shipboard satellite signal receivers	Navigational satellite; R&D model over 250 lbs.; operational, 50-100 lbs.; operational system: 4 satellites in random, near-circular 600-mi. orbits; SNAP nuclear generator; SCOUT booster	Operational system in process of being established for use by POLARIS subs; NASA also will use TRANSIT for civilian navigation satellite system

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
★**VELA HIGH ALTITUDE** (ARPA)	STL, prime; Los Alamos Scientific Lab/Aerospace, payload	20-sided, 485-lb. satellite for detection of nuclear explosions in space; 50,000-n.-mi. orbit; booster, ATLAS-AGENA	Successfully launched in October, 1963
★**VOYAGER** (NASA)	Study contracts, Avco Corp. & GE	Unmanned MARINER follow-on spacecraft to orbit Mars and Venus and to inject a capsule to the surface	Funds may be in FY '65 budget. Launches in 1967-70's period. Spacecraft of 6000 lbs. to be launched by three-stage SATURN IB or SATURN V
★**X-15** (NASA-AF-Navy)	North American, prime; Thiokol, propulsion; Sperry Gyroscope, inertial flight data system; Minneapolis-Honeywell, adaptive flight control electronics	Manned rocket plane; capable of 4000-mph plus flight at edge of space; single rocket engine develops 57,000 lbs. thrust	Powered flights in progress; unofficial records set: altitude 354,200 ft. and speed (4104 mph); hypersonic propulsion research program should run through 1966



Space Vehicles

AGENA (Air Force)	Lockheed, prime; Minneapolis-Honeywell, guidance; Bell, propulsion	1700-lb. upper stage; all-inertial guidance; re-start capability	Used in DISCOVERER, SAMOS and MIDAS programs; ATLAS, THOR boosters
BLUE SCOUT (Air Force)	Aeronutronic, prime; Ling-Temco-Vought, Inc., frame; Minneapolis-Honeywell, guidance; Aerojet/Hercules, Thiokol, propulsion	4-stage vehicle; payload cap., 150 lbs. (345 mi.) orbit, 100 lbs. probe (1610 mi.); range, over 6000 mi. vert. distance	Operational; based on NASA's SCOUT; space probe and small (150-lb.) satellite launch vehicle; also AF's Hyper-Environmental Test System
CENTAUR (NASA)	GD/Astronautics, prime; Pratt & Whitney, propulsion; Minneapolis-Honeywell, guidance	High-energy upper stage using a pair of LOX/liquid hydrogen engines; 30,000 lbs. total thrust, ATLAS D booster, capable of orbiting 8500 lbs.; 2300 lbs. to escape; 1300 lbs. on planetary flights	Development; program responsibility transferred from MSFC to Lewis; first flight test failed; late 1964 or early 1965 earliest possible operational date; next launch November, 1963
DELTA (NASA)	Douglas, prime; Bell Telephone Labs, guidance; Rocketdyne/Aerojet/ABL, propulsion	Successor to THOR-ABLE; upper stage guidance; 3-stage vehicle; 430 lb. payload capability in 500-mile orbit; two new versions—DSV-3A and DSV-3B—will have 700 and 800 lbs. payload capability, respectively; THOR missile comprises first stage	Launch vehicle for TIROS-ECHO; being used for other satellites and one deep space probe; 26 previously on order augmented by AF order for 12 more for NASA; DSV-3A used for EXPLORER XIV; DSV-3B to become operational this year; THRUST-AUGMENTED DELTA with 3 solid motor strap-ons also will be used
LITTLE JOE II (NASA)	General Dynamics/Convair, prime	Solid-propelled vehicle with thrust of 800,000 lbs.; launch vehicle for APOLLO suborbital flights	First launch Aug. 28, 1963, successful; six vehicles ordered thus far
NOVA (NASA)	Martin, study	Capability of NOVA under study; no firm concept but should offer significant improvement over C-5 (20-30 million lbs. 1st-stage thrust or nuclear upper stage)	Study to determine characteristics; operational target date post-1970 time period
ORION (Air Force)	General Atomic	Space booster propelled by series of atomic explosions to lift over 1000 tons into orbit	Studies; AF FY '64 request for $9.8 million denied by DOD; R&D continuing with funds re-programmed from FY '63
ROVER (NASA) AEC)	Los Alamos Scientific Labs, ROVER Prime; Aerojet, NERVA prime; Westinghouse, propulsion	First nuclear rocket: tests of KIWI, prototype of NERVA engine, under way	Kiwi tests to be completed this year. Development of Phoebus reactor initiated. No flight test program funded at present
★**SATURN I** (NASA)	Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler Corp.; S-IV, Douglas	2-stage vehicle for early boilerplate tests of APOLLO. 1st stage: 8 Rocketdyne H-1 engines; 2nd stage: 6 Pratt & Whitney RL10-A3 engines; 22,000 lbs. into 345-mi. orbit	Four flight tests of 1st stage successful; all flights with inert upper stage; first flight with live upper stages January 1964
★**SATURN I-B** (NASA)	Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler; S-IVB stage, Douglas	S-1: 8 H-1 engines; S-IVB: 1 J-2 engine; payload capability, 32,000 lbs. in 345-mi. orbit	Development; first flight 1965; boost APOLLO spacecraft biolerplate models, including lunar landing vehicle
SATURN V (Advanced Saturn) (NASA)	Systems engineering, assembly and guidance, Marshall Center; S-IC, Boeing; S-II, North American; S-IVB, Douglas; F-1, North American; J-2, North American	S-IC: 5 F-1 engines; S-II: 5 J-2 engines; S-IVB: J-2 engine; 120-ton payload in 345-mile orbit; 43 tons to escape velocity; 30 tons for planetary missions	R&D; first flight scheduled for 1966; prime booster for APOLLO missions; may also be used to boost orbiting space station
SCOUT (NASA)	L-T-V Astronautics, prime; Minneapolis-Honeywell, guidance; Aerojet-General/Hercules/Thiokol/ABL, propulsion	Solid four-stage satellite launcher; 300-lb. payload in 345-n.-mi. orbit	Operational payload being increased to 300 lbs.; NASA has ordered 23 more boosters
TITAN III (Air Force)	Martin, systems integration; United Technology, large solid boosters; Martin, TITAN II vehicle; Aerojet, liquid engines; Martin, standardized upper stage; AC Spark Plug, guidance	Quick-reaction vehicle for military space missions; will be used to boost DYNA-SOAR; 1st stage, two 120-in. solid motors; 2nd stage, TITAN II (storable propellants); 3rd stage, standardized vehicle to be developed; modified TITAN II guidance	Development; first flight late '64 (T-IIIA); Jan. '65 (T-IIIC); 17 development flights planned: 5 TITAN II core vehicles (A version), 12 full TITAN III's (C version); operational in 1965; 120-in. solid fired successfully July 20

Introducing...

Low Cost Inertial Guidance

Systron-Donner, designer and manufacturer of the DC-AUTOMET velocity control for the Army's Lance missile, now announces the first truly low cost solution to accurate short range inertial guidance and control.

It's a simplified airborne analog guidance computer which provides the same accurate results as more complex, more expensive guidance computer systems.

This low-cost guidance package was made possible by S-D's technical breakthrough in solid state operational amplifiers and integrators, the critical components of the system. These new amplifiers and integrators offer performance characteristics at least 10 times better than was feasible just a year ago.

If you need compactness as well as low cost, the entire S-D Guidance Computer isn't much bigger than a two-pound coffee can — and doesn't weigh much more.

To learn more about S-D's airborne systems and components, write to Flight Systems Group, Systron-Donner Corporation, Concord, California.

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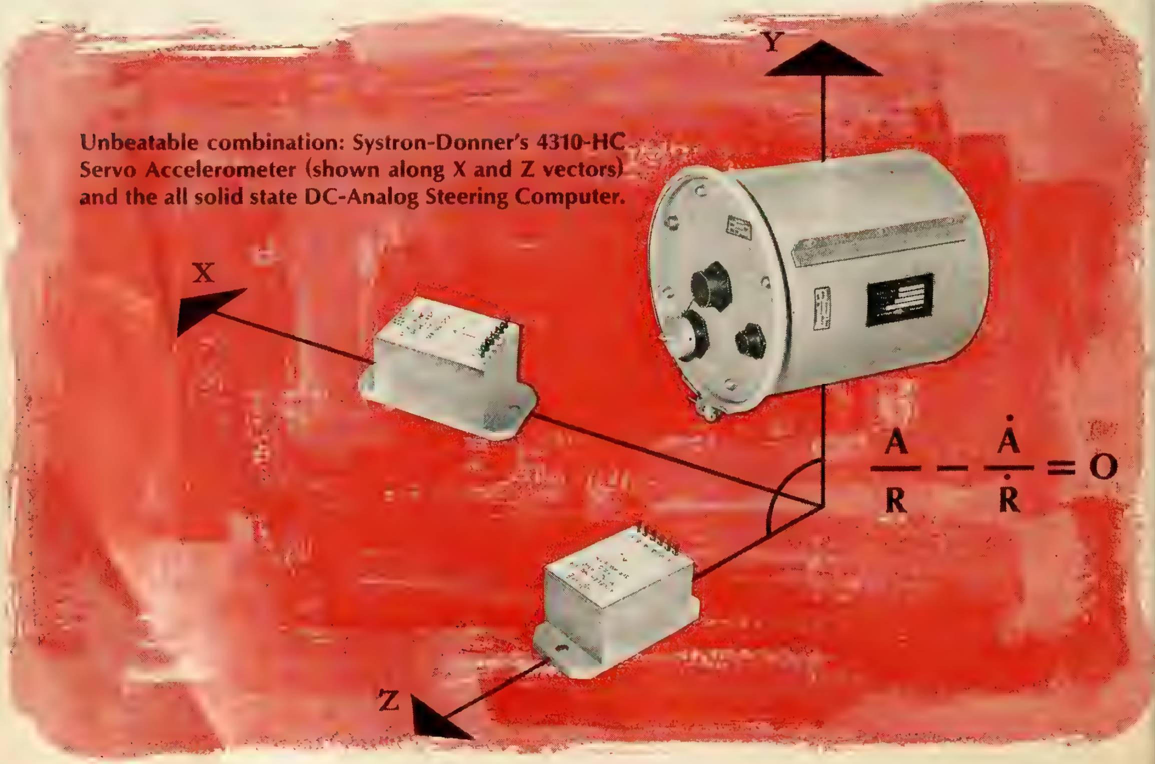

Unbeatable combination: Systron-Donner's 4310-HC Servo Accelerometer (shown along X and Z vectors) and the all solid state DC-Analog Steering Computer.

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Technical Countdown

ELECTRONICS

Solar Flare Warning System Planned

NASA's Goddard Space Flight Center is planning a solar radiation monitoring network to provide advance information on solar events to the manned space program. The program is tentatively slated to be initiated in the middle of this year with the radio astronomy equipment to be ordered nine months later, according to Dr. Robert Stone of the Center's Planetary Ionospheres Branch. The network will use three Deep Space Instrumentation Facilities—in Spain, Mexico and Australia—to flag Type 4A solar bursts. These bursts, in the decimeter region of the solar spectrum, give the longest lead time for predicting a solar event and thus are potentially the most helpful for warning astronauts. The data will be rushed on a realtime basis to NASA's Manned Spacecraft Center during the *Gemini* Program. Measurements will be taken at three frequencies—above, below and at the center frequency of 2,695 mc. Bandwidth will be 10 mc and dynamic range, 50 db. The antennas will be 10-ft. parabolic dishes driven by a clock control in hour angle plus manual override. Output format will be a single channel chart.

100-Milliwatt CW Gas Laser Tested

One hundred millawatts of continuous power has been produced by a new helium-neon gas laser developed by Perkin-Elmer Corp. The laboratory system employs two parallel plasma tubes. The output of one is coupled through precision optics to the other to produce a single high-intensity beam. The approach permits holding the overall length to 6 ft., weight to 35 lbs. The tubes measure 66 in. Excitation is accomplished solely by hot cathode direct current. Although the test wavelength was at 6,328 Å, P-E scientists disclosed that the use of external mirrors in the system would permit operation also at 1.15 or 3.39 microns.

New Modulator to Aid ECM Receivers

Three HRB-Singer, Inc., scientists have been awarded a patent covering a unique strip-transmission-line modulator that can be used in radio surveillance receivers. Described as small, lightweight and self-contained, the device will permit detection of pure CW or FM signals without degrading the operating capacity of a crystal video receiver. The inability to detect such non-amplitude-varying radiations has been a serious limitation in the past for these receivers, which are widely used for electronic countermeasures.

NMCS Scatter System Delayed

Air Force Project Build Back, a back-up military command communications system using many tropospheric-scatter sites throughout the continental United States, will be delayed—at least for a few months. The system as conceived would provide more than 100 low power stations employing 10-ft. paraboloidal-reflector antennas for over-the-horizon telecommunications for the National Military Command System. Bids have already been submitted by a number of system contractors.

VTM's Battered and Beaten, But Still Work

Voltage-tunable magnetrons have been undergoing a series of rigorous shock and vibration tests at General Electric's Schenectady Tube Dept. to prove their adaptability for missile/space use. Some, said a company spokesman, have been shock-tested to 1,600 g's (in excess of 80 times design-specification limits) without adverse effects on performance. One tube, a type ZM-6032, successfully withstood 45 successive blows of greater than 1,000 g's—the upper limit of the testing machine. The same tube, a 7.5-watt, 1.5-lb., bowl-magnet VTM, developed slight epozy cracking at 1,600 g's during another test sequence, but this did not reduce operating performance, GE claimed.

New Family of Tape Storage Tubes Perfected

A series of tape storage tubes using diffraction gratings instead of the normal mesh are capable of storing and reading image signals with a limiting resolution of 3,800 TV lines/in. More than 20,000 halftone copies have been read out from a single stored frame of information. Developed by the Westinghouse Electronic Tube Division, the grating is a solid piece of metal with grooves cut into one surface. A dielectric is deposited at a sharp angle to the surface, coating one side of each groove. As a camera tube, its sensitivity is comparable to photographic film with a speed index of ASA 100.

PROPULSION

Power Generating Rocket Exhausts

Naval Ordnance Test Station, China Lake, Calif., is firing rocket engine exhausts through the hole in a doughnut-shaped, supercold and superconducting magnet in a project aimed at better understanding of the magneto-transport properties of the thermally generated plasmas. The work has proved feasibility of generating electricity from rocket exhaust, according to NOTS spokesmen. Dubbed THERMA, the project is typical of several being conducted in NOTS' Propulsion Development department in fluid control and advanced energy conversion involving interaction of electric and magnetic fields with electrically conducting fluids. The magnet is maintained at a temperature of —452°F, with liquid helium, as rocket exhaust gases flow through the magnetic field at a temperature of 5,700°F.

Barrier Flow Experiment Successful

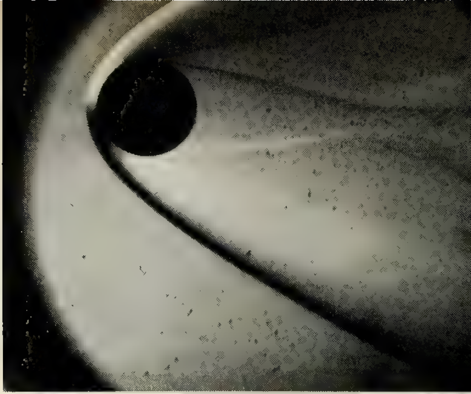
A technique called "barrier flow" by its developers at Bell Aerosystems Co. permits the burning of high energy propellant combinations with the same ablative materials used in relatively low-energy systems. Bell engineers have fired a number of ablative rockets using a fluorine-hydrazine combination with combustion temperatures up to 7,000°F. Throat erosion of less than 1% has been achieved in a full duration test and this result agreed very well with prior thermo-dynamic analysis. Bell specialists have determined the feasibility of using ablatives in high-energy systems through the barrier concept.

MATERIALS

Heat May Replace Optical Pumping

Possibility of lasering materials by heat instead of by optical pumping is being studied by Electro-Optical Systems, Inc., Pasadena, Calif. Although ruby laser performance degrades with temperature rise, cesium and some of the alkaline earths show spectral lines narrow enough to promise laser action at temperatures as high as 1.200°C. Present studies at EOS make use of joule heating, but aim of the work is to develop a laser that can be pumped by heat from the Sun or from a nuclear reactor.

Gemini Photos May Assist in Re-entry Wake Research


SCHLIEREN PHOTO of spherical re-entry model shows neck of the wake at center.

by Russell Hawkes

INDUSTRY CAN look for a proposal that cameras or other instruments be installed aboard an early *Gemini* spacecraft to collect information about the hot wake by which returning spacecraft and re-entering ballistic missiles are most readily tracked.

Leading wake researchers favor such a proposal after a half-day conference with astronauts who reported on the visual appearance of *Mercury* spacecraft wakes during re-entry from orbit. Dr. Leslie Hromas of TRW Space Technology Laboratories said the astronauts who have experienced orbital flights were able to contribute four or five key observations resolving controversy among theoretical analysts.

The astronauts testified that a disc-shaped or ring-shaped (they disagreed on this point) fireball forms in the wake about 20 ft. behind the capsule. They all agreed that the fireballs looked something like the "shock diamonds" that appear in the supersonic exhaust of an afterburning turbojet engine or a rocket. John Glenn disagreed about the distance. He set it at nearer 50 ft. from the capsule. In general they agreed that the fireballs were about half the diameter of the capsule.

- **Several questions answered**—The astronauts were able to resolve controversy among experts over whether the fireballs fluctuate in position, shape or intensity. They reported that it remains constant except when it is caused to dance around by changes and oscillations in the attitude of the spacecraft.

Color of the fireball is of interest to analysts since it reveals information about the energy mechanisms within it. Reports of the four *Mercury* astronauts who have made orbital flights are less conclusive about this. Two astronauts reported that the fireballs they observed were bright orange and the other two reported that they were bright green.

In both cases analysts believe the color was determined by materials ablated from the spacecraft. However, it is believed that air would also glow visibly in an uncontaminated wake.

During discussions of the flame color and shape, astronaut Walter M. Schirra produced a 100-shade collection of crayons, and the astronauts attempted to draw the wakes in trapezoidal window-shaped pictures as they appeared from inside the spacecraft. The drawings have been incorporated in a report now available from the Advanced Research Projects Agency.

- **Wave thermal configuration**—The wake of a re-entry vehicle consists of a wide-spreading shock wave off the front end within which is a region of inviscid flow with temperatures of only about 2,000° K, compared to 8,000° K at the stagnation point in the center of the vehicle's forward face.

Directly behind the spacecraft is a "base region" of viscous flow and high temperatures tapering to a neck that is probably the site of the fireball drawn by the astronauts. The temperature there is about 4,000° or 5,000° K. Behind this stretches the wake proper, its diameter gradually increasing with the cube root of the distance downstream.

The amount of energy in the whole flow structure is very large. The temperature in the wake 1,000 re-entry vehicle diameters behind the spacecraft is still as high as 1,000° K.

- **Flow velocities**—The velocity of the flow with respect to the spacecraft rises with the distance from the spacecraft. The astronauts all agreed that air within the conical base region apparently moves very slowly relative to the spacecraft. All reported that jettisoned retro-pack straps floated close to the spacecraft neck for four or five seconds before drifting out of the base region and being whisked away in the higher velocities of the inviscid flow. This time period included a large fraction of the re-entry during which about 100,000 ft. of altitude was lost.

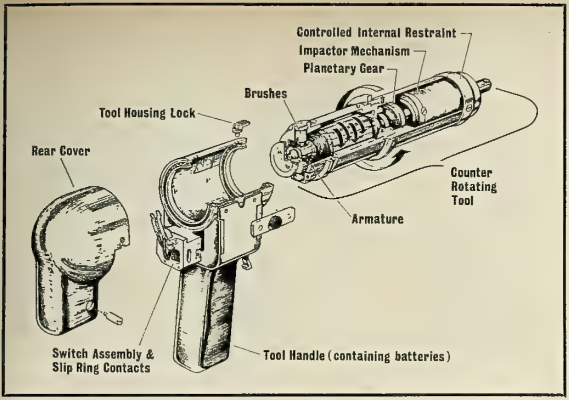
The most valuable tool for ground-based research on re-entry wakes has been the ballistic range. Very small re-entry vehicle models fired from various types of guns and photographed in flight have revealed much of what is known about the flow structure around an object moving at re-entry speeds.

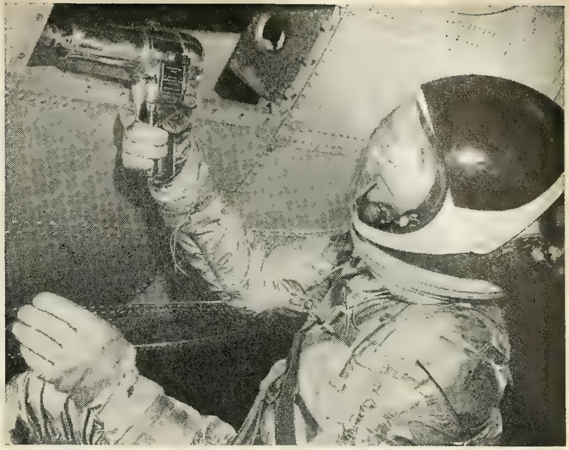
- **Wake research grows**—Re-entry wakes are providing a booming field of research and are of interest to virtually everyone in the missile/space business. Spacecraft designers study wakes for clues to solution of communications black-outs, which occur during the heat pulse of re-entry. Those developing ballistic missile defenses study the wake as the most easily tracked phenomenon associated with such missiles. Ballistic missile developers study them in the hope of making the wake invisible or making decoys with wakes that cannot be distinguished from wakes of warheads.

STL, one of the leading centers of wake research, is interested primarily from the latter point of view since USAF, its chief customer, is a ballistic missile operator. Dr. Hromas is optimistic about the chance of making wakes entirely transparent to radar.

- **Vehicle shape determines wake**—The geometry of the vehicle has important effects upon the geometry and intensity of wake phenomena. The slim, low drag bodies used as missile warheads and probably to be used for future spacecraft produce a weaker shock wave, a cooler inviscid region, a more turbulent wake and a trail of observable ions and electrons only a fifth to a tenth as long as that behind a blunt body.

The visible wake had not been anticipated before the launch of the first manned *Mercury* capsule into orbit. It had been planned that astronaut Cooper would use a special hand-held camera to record data about the wake during his re-entry on the last *Mercury* flight; however, the necessity to make a pilot-controlled re-entry made it impossible to complete this task. ■


Controlled Internal Restraint
Impactor Mechanism
Planetary Gear
Brushes
Tool Housing Lock
Rear Cover
Counter Rotating Tool
Armature
Switch Assembly & Slip Ring Contacts
Tool Handle (containing batteries)



ABOVE: Drawing shows key parts of powered space tool developed for the Air Force by Martin Co. and Black & Decker Manufacturing Co. RIGHT: Martin engineer demonstrates tool.

space support

Space Tool for Apollo Can Deliver 50 Ft.-Lbs. of Work

Middle River, Md.—What is reported to be the first powered space tool has been demonstrated by the Baltimore Division of the Martin Co.

The device, which can be used as a screwdriver, wrench, drill, grinder or thread tap by changing attachments, has a reactive torque of 0.5 in.-oz., but can deliver about 50 ft.-lbs. of work. It transfers no rotational torque to the user, although there is minimal pushing away from the work surface.

The tool was designed for use in repairing vehicles of the *Apollo* class and for orbital assembly of space stations. Spokesmen for the Air Force Systems Command, which contracted for the development, said that the Air Force is also taking a long-range view to the possibility of maintaining unmanned satellites in space by astronauts.

- **Reducing torque**—Martin Co. engineer Martin Goldman, developer of the device, said the reduction in reaction torque is accomplished this way:

—First, the armature begins turning. The entire motor and case are designed to rotate on ball bearings inside the device.

—A controlled restraint system transfers the reaction from the motor to the output shaft.

—The work of the motor loads up a spring, which results in an impact mechanism transferring this power to the output shaft. This impact mechanism, operating on the same principle as those used to tighten automobile lugs, hits about 1,700 times a minute.

The reactive torque of 0.5 in.-oz. is constant, Martin engineers say. The only reaction to different loadings will be in friction in the motor case bearings. A widely used home utility drill tool, for comparison, produces 8 ft.-lbs., or 1,536 in.-oz.

Extensive vacuum chamber tests have been conducted, and the device has operated continuously for two hours without exceeding a temperature of 85°F. Arcing of the motor brushes in vacuum is no problem, although developers said they at first feared this.

Future environmental tests—vacuum and cold, vacuum and extreme heat—will be carried out. Black and Decker Manufacturing Co. engineers said that final design may require some exotic materials to withstand the environment.

- **Maintenance**—Lubrication of the instrument presents no problem, even in the vacuum, spokesmen say. A paraffin base, silicon oil was used in vacuum chamber tests in which the tool was left for a week at simulated 520,000 ft. altitude.

All components, including the five-cell nickel-cadmium battery, were developed by Martin, in conjunction with Black and Decker. Work was performed under a $24,000 AFSC contract from Wright-Patterson Aero-Propulsion Laboratory.

The device has been tested in actual weightlessness in parabolic flight in an Air Force KC-135 tanker. For demonstration and development purposes, a five-degree-of-freedom simulator is used.

According to Martin developers, the only problem remaining is a slight pushing away when the tool must be held against the working surface, such as in driving screws. This, they said, would require some slight restraint mechanism to hold the astronaut in place.

Air Force spokesmen said work is now underway at Wright-Patterson to develop adhesive type restraint lines. ■

Contractor Gets Steady Check on Profits With New PERT-type System

Output of inexpensive computer program developed by Computer Dynamics treats profits as pieces of hardware

by William Beller

A PERT-type program able to show a continuous picture of profits throughout the life of a contract has been developed.

Shaping and molding of profits as the contract passes through design, procurement, engineering and fabrication, for instance, can be monitored as though the profits themselves were pieces of hardware being developed under a PERT/Time system.

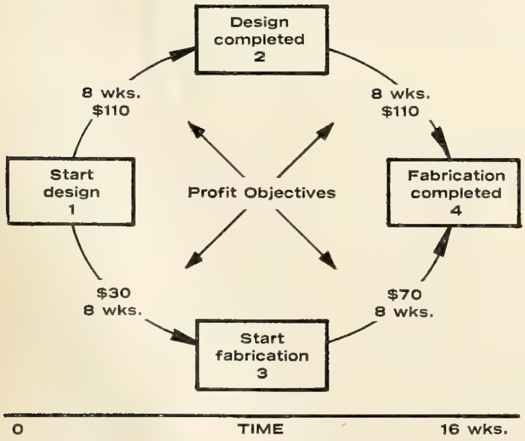
The advantage of having a running picture of the profits a contract is bringing in, or perhaps not bringing in, is difficult to overestimate from the viewpoint of the top management of a company. It ranks with the advantage operational management gets from the scheduling data put out by PERT/Time, and in the near future, from cost data put out by PERT/Cost.

So contends B. J. Hansen, Jr., vice president of Computer Dynamics, Inc., of Silver Spring, Md., and formerly one of the original Lockheed team that devised PERT/Time for *Polaris*.

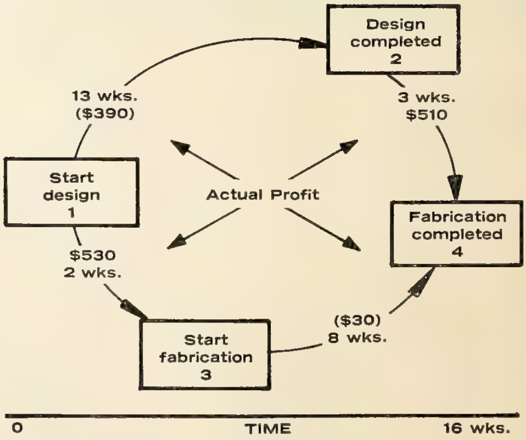
- **Extends PERT/Cost**—For the past two years, Hansen has worked in a general way on a method for getting

HYPOTHETICAL EXAMPLE OF FIXED-PRICE CONTRACT

NEGOTIATED TERMS							AT END OF CONTRACT					
Activity	Job Package	Negotiated Time	Estimated Cost	Profit Objective		Estimated Price	Activity	Job Package	Actual Time	Profit Objective	Actual Cost	Actual Profit
				% of Cost	Amount							
1 to 2	Design	8 wks	$1,000	11	$110	$1,110	1 to 2	Design	13 wks	$110	$1,500	($390)
1 to 3	Procurement	8 wks	1,000	3	30	1,030	1 to 3	Procurement	2 wks	30	500	530
2 to 4	Engineering	8 wks	1,000	11	110	1,110	2 to 4	Engineering	3 wks	110	500	510
3 to 4	Fabrication	8 wks	1,000	7	70	1,070	3 to 4	Fabrication	8 wks	70	1,100	(30)
	Totals		$4,000		$320	$4,320		Totals		$320	$3,700	$620


Design completed 2
8 wks. $110
8 wks. $110
Start design 1
Profit Objectives
Fabrication completed 4
$30 8 wks.
$70 8 wks.
Start fabrication 3
0
TIME
16 wks.

Profit/PERT for negotiated terms.


Design completed 2
13 wks. ($390)
3 wks. $510
Start design 1
Actual Profit
Fabrication completed 4
$530 2 wks.
($30) 8 wks.
Start fabrication 3
0
TIME
16 wks.

Profit/PERT at end of contract.

profit as the output of a computer routine that would be easy to apply and relatively cheap to run. For this purpose, he decided to augment the PERT/Cost system, not only because it is based on classical PERT/Time, but also because it is approved for use on current contracts of the Department of Defense, including *TFX, Mauler, Subroc, Titan III, MMRBM, Lance* and *Polaris.*

His goal was reached when Virginia Iandiorio, Computer Dynamics professional staff member, made operational a PERT/Cost system for the small-to-medium sized computers instead of for the larger and more expensive computers generally recommended, and added the inputs needed for "Profit/PERT."

Top executives need to see the profit picture while they can still do something about changing it if it is going bad, or improving it if the opportunity is there. At a board of directors meeting, for example, where the result of a recently completed contract is being discussed, an attitude of "Well, we really got burned on that one. Let's not go into this kind of a venture again," is after-the-fact.

No business lesson was learned, such as, "We lost money because we emphasized the 'low profit' area of production and didn't put enough effort into the 'high profit' area of design."

This knowledge will become increasingly relevant to the successful operation of any major contract, particularly with the complexities brought in by the weighted guidelines for profit, which are being introduced with incentive contracting. In fact, as of the first of this year, weighted guidelines must be used for establishing the profits for all negotiated contracts.

The problem of knowing the current state of the profit picture without the help of a computerized system can be imagined, especially in view of the range of DOD profit factors, for example—engineering labor, 9 to 15%; manufacturing overhead, 4 to 7%; manufacturing labor, 5 to 9%.

● **Not a new problem**—Some executives complain about the difficulty of getting a true profit picture at any time earlier than the completion of a contract, even when operating on a fixed-price basis. The answer seems to be that in a large project, a comptroller cannot possibly have all the factors at hand at any time before completion of the contract any more than a general manager can keep track of such a project without the help of PERT or some other computerized system. Yet profit, the reason for a private corporation's existence, is seemingly the last major item to be given systems consideration.

There are many examples of the government asking for contract changes whose effects can be seen only dimly. For instance, a contract administrator may interpret a contract specification in broad rather than in the specific terms the contractor had in mind when he signed the contract.

If there is not a subsequent meeting of minds, the contractor is usually the loser. "He might fight harder, and with more effect, if he had a projection of his profit picture," says Hansen, suggesting Profit/PERT as one possible answer.

Clearly, all work in business is not necessarily profit-making. The task, then, was to develop a means to show where the profit-making phases of work are

```
                              PROFIT PERT INPUT DATA SHEET

                     CHARGE NUMBER    PLANNED    ACTUAL    PROFIT
                                                           FACTOR

                      00001-00002      1,000      1,500      011
                      00001-00003      1,000        500      003
                      00002-00004      1,000        600      011
                      00003-00004      1,000      1,100      007

                                      PERT COST
                               MANAGEMENT PROFIT REPORT

                    REPORTING ORGN.        CONTRACT NO.               REPORT DATES
ABC-MISSILE & GHE   XYZ - A&S DIVN.      63(600)28369A       TERM (SPAN) - TOTAL PROJECT
                                                             OUT OF DATE - END OF PROJECT
LEVEL/SUMMARY ITEM:  7/DES.,PROC.,ENG.,FAB. 111111           RELEASE DATE - 13 JAN 64

                          NEGOTIATED                                            ACTUAL
                          COST/PROFIT                                         COST/PROFIT

       ITEM             PLANNED        PROFIT         CONTRACT      ACTUAL        PROFIT
                          COST         FACTOR           PRICE        COST         (LOSS)

DES.,PROC.,ENG.,FAB.
111111                   4,000           8%             4,320        3,700          620
DESIGN
00001-00002              1,000          11%             1,110        1,500        ( 390)
PROCUREMENT
00001-00003              1,000           3%             1,030          500          530
ENGINEERING
00002-00003              1,000          11%             1,110          600          510
FABRICATION
00003-00004              1,000           7%             1,070        1,100         ( 30)
```

Which haystack hides the needle?

It's hard enough to find a needle in one haystack. But it *really* gets difficult when the needle moves from stack to stack.

This analogy describes the concept behind a new kind of missile system now being developed: MMRBM—Mobile Mid Range Ballistic Missile.

Take an advanced, highly-accurate missile. Put it into a compact, self-contained "package"—from which it can be launched at a moment's notice. Then move it where you want it.

Like our peripatetic needle, the unique advantage of MMRBM is in its mobility; for example, mounted on a "semi" truck trailer. The total mobility of the weapon system enables units to be parked at widely dispersed parking areas and moved frequently or to operate in a continuously mobile fashion over highways and secondary roads. Widely dispersed and moving in unpredictable patterns, these MMRBM's would be virtually impossible to keep under surveillance and to target. No economical defense can no
be visualized.

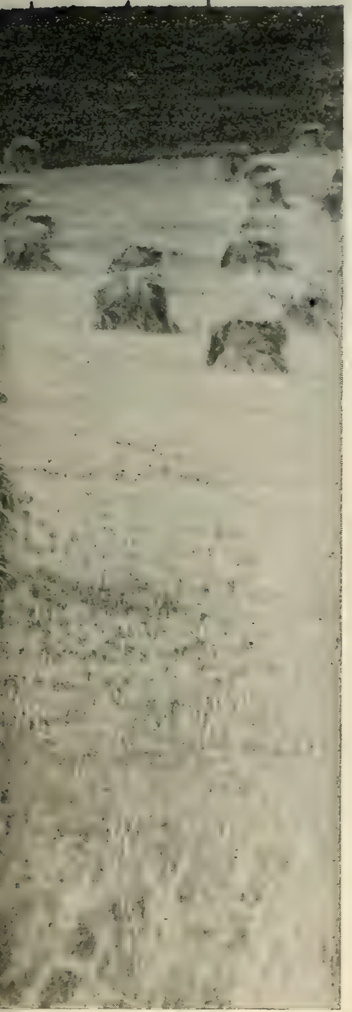
These MMRBM "packages" would al
be "air-liftable." Stockpiled at strateg
points, they could be put aboard j
transports and be delivered to troub
spots in hours.

Throughout human history, man h
recognized the need to provide for his a
his neighbor's safety through streng
The MMRBM system—versatile, fle
ble, economical—adds a new dimensi

Creating a new world with electronics

HUGHES

HUGHES AIRCRAFT COMPANY



the capability for defense in our time. ughes, as the Integration, Assembly and eckout contractor, is proud to be a mber of the industry team working on s system for the U.S. Air Force.

ıny important career opportunities are ailable for engineers and scientists on MMRBM program. You are invited ubmit your resume now to: Mr. Robert Martin, 11940 W. Jefferson Blvd., lver City 16, California. Hughes is equal opportunity employer.

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and to get the most out of these. By flagging these areas, Profit/PERT apparently has the advantage of also showing when a facility, such as a test facility, may be piling up so much work that the delays are causing a loss in the profit margin.

Thus, to bid on another contract requiring use of the same test facility might even bring a loss to the company in terms of cutting down the incentive factor. In this way, Profit/PERT can be used to tell whether the time is right, from a profit standpoint, to bid on current RFP's.

- **Use profit as incentive**—Only the higher echelon officials usually know the profit structure of a company and subsequently in the most general fashion, the stockholders. Hansen proposes a radical move: let the lower levels see the profit picture, too, in order to increase their motivation.

Even if the percent-profit figures or the dollar-profit figures are privileged information for the higher officials—for labor as well as government reasons—the profit picture can still be drawn on a unit scale, which, incidentally, is the way a computer seems to prefer to work.

As with PERT/Time, the profit picture can be given in less detail as the level of management rises. For the operating level, the profit picture can be given in terms of operating profit. To the next level, it can be given as profit before taxes, and to the highest level, possibly, profit after taxes.

In the example shown here, the profit picture is shown both at the time of contract negotiation and at the end of the contract. In actual practice, Profit/PERT would show at each reporting period—about two weeks apart—the profit picture for the past, that is, up to the present; for the present, that is, up to the next reporting cycle, and for the projected future. This is no different from conventional PERT reporting.

- **Mechanics of Profit/PERT**—Profit/PERT calculations lend themselves well to computer processing. Rather than develop a computer program for this specific purpose, Computer Dynamics has incorporated the necessary computations into its existing program for the DOD/NASA PERT/Cost system. This system has been designed for the small-to-medium sized computer on the basis of two factors: running costs are far less—$35/hour for small-to-medium versus $700/hour for large scale. There are many more small-to-medium installations.

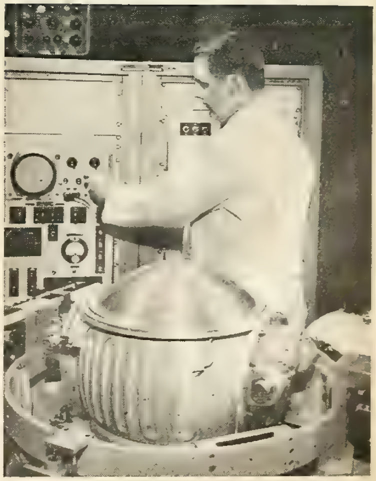
The input data required in Profit/PERT are minimal and can be entered into the computer in the same form as is normal PERT/Cost data. As shown in the highly simplified "Profit/PERT Input Data Sheet," the additional information necessary is a profit factor, and all other pertinent factors, given in percentage form for each charge number. The other data are normally used in PERT/Cost.

In the computer, the actual cost of work and materials charged to the item is subtracted from the contract price. The difference represents a loss if negative, a profit if positive.

Within the framework of the PERT/Cost system, these data are displayed at any desired level or levels of the work breakdown structure, for each summary item on the level. The first line of the report shows the total data for the summary item. Subsequent lines give the data for each component item emanating from that summary item.

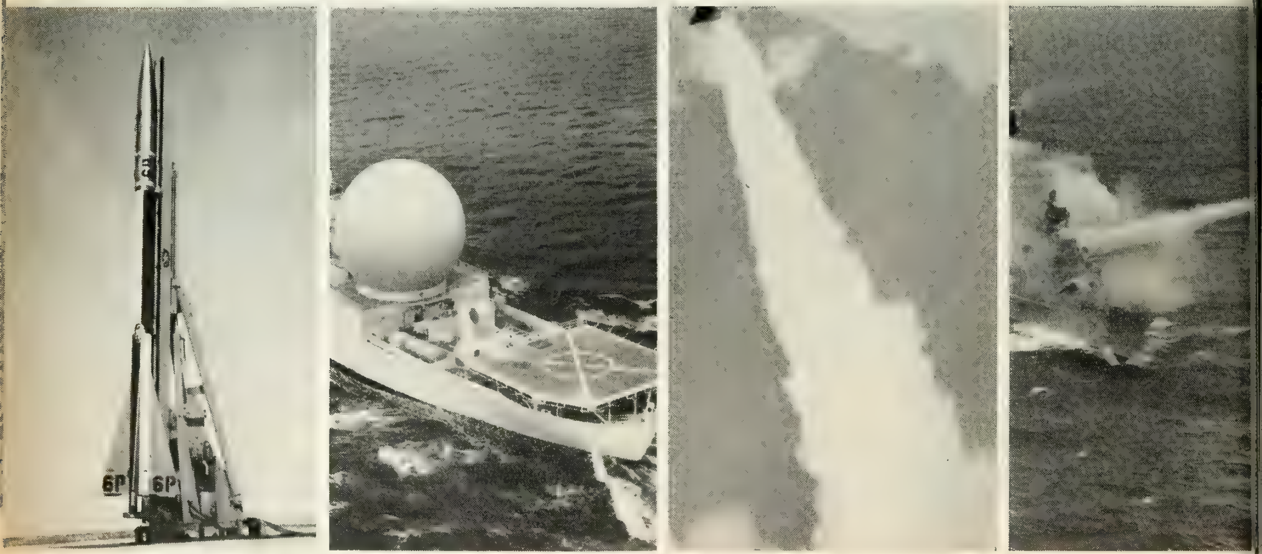
Even if a company does make significant profits through judicious profit planning, the money should perhaps not be converted too quickly into dividends. Competitors delight in pointing out, "DOD giveth and the Renegotiation Board taketh away." ■

Command Module IMU Undergoes First Testing



TECHNICIAN at General Motors' AC Spark Plug Div. begins testing of the first pre-production inertial measurement unit for the Apollo Command Module navigation and guidance system. The AC-Milwaukee Operations will also build the IMU for the Lunar Excursion Module, and will integrate and test the complete airborne package before vehicle installation.

Tactical rocket probes for over-the-horizon intelligence will fill a vital need for our Armed Forces.



Getting the job done takes this kind of electronics systems background.

Bendix background in electronics and systems management includes being system manager for AN/AMQ-1
weather reconnaissance program, system integration manager for the Navy's satellite communication's shi
board terminal on the USNS Kingsport, system manager for an Air Force rocket communications syster
and system manager for the Talos missile. This collective experience is currently being applied to activ
rocket probe programs for over-the-horizon intelligence at the Bendix Systems Division, Ann Arbor, Michiga

Bendix Systems Division

THE Bendix CORPORATION

WHERE IDEA
UNLOCK
THE FUTURE

Circle No. 6 on Subscriber Service Card

Mergers and Acquisitions

The Singer Co. has reached tentative agreement with Gertsch Products, Inc., Los Angeles, to purchase Gertsch for $3,503,510. Gertsch designs, manufactures and markets meters, transformers and other electronics instruments. Singer is to assume certain Gertsch liabilities in the transaction. . . . *Electronics Accounting Card Corp., High Point, N.C., has agreed to acquire all stock of Middle States Mfg. Co., Riverton, N.J. Both firms manufacture data processing cards. Purchase price was not disclosed.* . . . Fansteel Metallurgical Corp., Chicago, has agreed to acquire some assets of Stauffer Chemical Co., including Stauffer's electron beam furnaces, refractory metalworking equipment and related laboratory facilities. Fansteel produces tungsten, molybdenum, tantalum and columbian products. . . . *International Telephone and Telegraph Corp. has acquired the assets of John J. Nesbitt, Inc., Philadelphia. The new operation will be known as ITT Nesbitt, Inc. Nesbitt was a producer of heating, ventilating and air conditioning equipment.* . . . Acton Laboratories, Inc., a subsidiary of Bowmar Instrument Corp., Fort Wayne, Ind., has acquired Electronics Systems, Inc., of Boston. ESI will operate as a wholly owned subsidiary of Acton. Acton will continue to manufacture equipment for measurement and control of electrical phase and phase and frequency trackers.

New Firms and Divisions

The Boeing Co.'s Aero-Space Div. has been reorganized to place increased emphasis on new business activities. Vice President George Snyder will head a proposal team for the *Manned Orbiting Laboratory* program. Robert J. Hileberg will manage the *Lunar Orbiting Satellite* program recently awarded by NASA. Of the division's four branches, only the *Saturn* booster branch remains unchanged. The *X-20* and *Bomarc* branches have been discontinued.

International

Douglas Aircraft Co. has established an International Marketing Office at 34 Rue Jean Giraudoux in Paris as a field support activity of its Corporate International Marketing Dept. The Paris office will work in coordination with the firm's principal European office in Geneva. . . . *Radiation Incorporated, Philadelphia, and Melborne, Fla., has licensed a French electronics firm, Intertechnique, to manufacture and sell pulse code modulation telemetry equipment throughout the European Common Market, Israel and the NATO nations with the exception of Great Britain. Contract is for 10 years.* . . . Telemetrics, Inc., has appointed Allan Crawford Associates, Ltd., Willowdale, Toronto, as exclusive Canadian sales representative for its telemetry ground station equipment. . . . *The General Electric Co. has made the following changes in its International Group: The Group will now consist of four divisions—the IGE Export Div. (formerly the International General Electric Co. Div.) and three newly formed divisions to be known as the Area Divisions—Far East, Europe and Latin America.*

Industry Facilities

Philco Corp.'s Aeronutronic Div. is installing environmental testing equipment costing approximately $218,000 in its Environmental Test Laboratory, Newport Beach, Calif. The facilities include vibration testing equipment and a central control and monitoring instrumentation room. . . . *Unitrode Transistor Products, Inc., has begun construction of a new building in Watertown, Mass. The plant will provide 18,000 sq. ft. of production area and 12,000 sq. ft. for research and development activities and administrative offices. Unitrode manufactures electronic components for the missile/space field.* . . . Thiokol Chemical Corp.'s Rocket Operations Div. has opened a regional office in Denver at 280 Columbine St. . . . *General Electric Co. has announced plans to construct a $1-million, 35,000-sq.-ft. research and development laboratory at its laminated products department in Coshocton, Ohio. Completion is expected in mid-1964.* . . . Borders Electronics Co. is moving its headquarters to a 38,000-sq.-ft. facility in Pennsauken, N.J. The move expands Borders' laboratory and manufacturing facilities by five times that of present headquarters in Philadelphia.

Company Representatives

De Mornay-Bonardi Div., Datapulse, Inc., manufacturers of microwave test instruments and components, has appointed RF Associates, Inglewood, Calif., sales and engineering representative in California, Arizona and Nevada. Connaughton and Co., Boston, has been named sales and engineering representative in the New England area. . . . *General Electric Co.'s Silicone Products Dept., Waterford, N.Y., has named Lawrence Electronic Co., Dallas, a stocking distributor of GE silicone products in the Southwest.* . . . Ultronix, Inc., San Mateo, Calif., has appointed Compar Corp., Burlingame, Calif., as engineering representative and exclusive national distributor of its line of high-precision wirewound resistors. . . . *Vishay Instruments, Inc., Malvern, Pa., has appointed EMC Technology, Inc., Philadelphia, as exclusive manager of its national marketing and application engineering of its precision-etched metal film resistor line.* . . . Allegany Instrument Co., a division of Textron Electronics, Inc., has apopinted Gentry Associates, Inc., as its authorized sales representative in Florida, Georgia, Alabama, Mississippi, South Carolina, North Carolina and Tennessee. GA maintains offices in Orlando, Fla.; St. Petersburg, Fla.; Huntsville, Ala.; and Burlington, N.C.

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1961—1963

(36 months)

Missiles and Rockets

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—1100 pages

Aviation Week

—450 pages

Missiles & Rockets is the only major missile/space publication to show consecutive gains since 1960.*

**Source: M/R Research Dept.*

An American Aviation Publication
1001 Vermont Ave., N.W.
Washington, D.C., 20005

contracts

AIR FORCE

$152,600,000—**North American Aviation, Inc., Autonetics Div.,** Anaheim, Calif., for continued development of the guidance, flight-control and aerospace ground equipment for the *Minuteman* missile.

$30,414,000—**Martin Co.,** Baltimore, for design and production of *Titan III* boosters for space exploration.

$25,831,115—**Westinghouse Electric Corp.,** Pittsburgh, for refueling and reactor plant equipment for nuclear-powered submarines (four contracts).

$15,700,000—**Radio Corp. of America, Defense Electronic Products Div.,** Camden, N.J., for continued work on an early warning system for ballistic missiles.

$15,400,000—**United Technology Center,** Sunnyvale, Calif., for design and production of large solid rocket motors.

$14,200,000—**Boeing Co.,** Seattle, for further work on *Minuteman* missiles at Whiteman AFB, Mont.

$4,400,000—**Aerojet-General Corp.,** Sacramento, Calif., for further work on *Titan III* liquid rocket engines.

$4,000,000—**General Electric Co.,** Syracuse, N.Y., for a weapons-control system.

$2,700,000—**Philco Corp., Aeronutronic Div.,** Newport Beach, Calif., for engineering services related to the *Shillelagh* missile.

$2,500,000—**Hazeltine Corp.,** Little Neck, N.Y., for production of improved electronic equipment for an undesignated radar effort.

$2,400,000—**Mitre Corp.,** Bedford, Mass., for continued research and development in command and control systems.

$2,200,000—**Hercules Powder Co.,** Wilmington, Del., for continued production of rocket engines for stage III motors for the *Minuteman* missile.

$1,700,000—**Philco Corp., TechRep Div.,** Philadelphia, for provision of systems engineering technicians at radar installations throughout the continental U.S.

$1,500,000—**Loral Electronics Corp.,** New York City, for work on electronic reconnaissance sets.

$1,400,000—**Thiokol Chemical Corp.,** Bristol, Pa., for further research and development on solid rocket motors at an undisclosed location.

$1,200,000—**General Electric Co.,** Syracuse, N.Y., for a weapons-control system.

$1,100,000—**General Dynamics Corp., Astronautics Div.,** San Diego, Calif., for continued production of *Atlas* space boosters.

$1,000,000—**Lockheed Missiles & Space Co.,** Sunnyvale Calif., for continued work on unspecified satellites.

$1,000,000—**General Dynamics Corp., Astronautics Div.,** San Diego, for work on *Atlas* missiles.

$1,000,000—**Hughes Aircraft Co.,** Culver City, Calif., for an automatic test equipment system for checkout of *Titan II* and *Minuteman* inertial guidance systems.

$79,455—**Trustees of Princeton University,** N.J., for a study of propellant ignition and igniter characteristics.

$78,660—**Penta Laboratories, Inc.,** Santa Barbara, Calif., for 690 electron tubes.

$76,236—**Precision Instrument Co.,** Palo Alto, Calif., for a study and investigation of coherent light recording techniques.

$65,006—**Motorola, Inc., Semiconductor Div.,** Phoenix, Ariz., for a 12-month study of failure mechanisms of metal-dielectric interfaces.

ARMY

$13,100,000—**Bendix Corp.,** Teterboro, N.J., fo work on the guidance and control system fo the *Pershing* missile.

$10,700,000—**Sperry Rand Corp.,** Salt Lake Cit Utah, for *Sergeant* missile components.

$5,300,000—**Dynalectron Corp.,** Washington, D.C for the collection of missile flight test data a White Sands-Holloman Missile Range.

$4,000,000—**Control Data Corp.,** Minneapolis, fo work in research and development on a classi fied project (two contracts).

$3,500,000—**Raytheon Co.,** Andover, Mass., fo *Hawk* missile guidance and control work.

$3,200,000—**General Electric Co.,** New York Cit for work on the advanced *Nike-Hercules* AB radar system at an undisclosed location.

$1,900,000—**Rohm & Haas Co.,** Huntsville, Ala for solid-rocket research and developmen work.

$1,900,000—**Esso Research and Engineering Co** Linden, N.J., for research on solid rocket pro pellants.

$1,900,000—**Honeywell Regulator Co.,** Minnea polis, for research and development on a unspecified warhead.

$1,600,000—**Emerson Electric Manufacturing Co** St. Louis, for *Honest John* rocket motor part production.

$1,500,000—**Telecomputing Corp.,** Panama Cit Calif., for space data handling at the Whit Sands Missile Range.

$1,300,000—**Lionel Corp.,** Garland, Tex., fo *Hawk* missile metal motor parts.

$1,100,000—**Standard Oil Co.,** Linden, N.J., fo fuel cell research and development.

$1,000,000—**Hughes Aircraft Co.,** Culver Cit Calif., for further work on the *Mauler* antitan missile.

$665,000—**Bell Aerosystems Co.,** Buffalo, N.Y for supplying high-performance acceleromete for the *Sergeant* missile.

$90,040—**Hercules Powder Co.,** Wilmington, Del for a test plant to isolate the cause of prope lant grain fracture in the *Little John* missil rocket motor.

$47,669—**American Bosch Arma Corp.,** Sprin field, Mass., for nozzle assemblies.

NAVY

$12,500,000—**Sperry Rand Corp., Sperry Gyro scope Div.,** Great Neck, N.Y., for work relate to the *Polaris* missile and submarine progra (four contracts).

$5,700,000—**Honeywell Regulator Co.,** Minne polis, for *Polaris A-3* missile accelerometers.

$3,500,000—**General Electric Co.,** Pittsfield, Mass for *Polaris* missile components.

$3,500,000—**Honeywell Regulator Co.,** Minne polis, for *Polaris* missile components.

$2,200,000—**General Electric Co.,** Philadelphi for work on the *Polaris* missile program.

$1,900,000—**North American Aviation, Inc.,** Co umbus, Ohio, for work on a classified projec

$1,585,067—**Thiokol Chemical Corp., Reactio Motors Div.,** Bristol, Pa., for continued pr duction of the *Bullpup A* packaged liquid e gine.

$1,500,000—**Hercules Powder Co.,** Wilmingto Del., for research and development on pr pulsion systems for *Polaris* missiles.

$1,000,000—**International Telephone and Tel graph Corp.,** Fort Wayne, Ind., for researc and development of image-handling equipme for use with surveillance systems.

$505,393—**Chromcraft Corp.,** St. Louis, for rock launchers.

VIBRATION NEWS

MB ELECTRONICS · *A DIVISION OF TEXTRON ELECTRONICS, INC.*
Representatives in principal cities throughout the world

MB now offers vibration test systems at prices as low as $1075

Now you can buy a high quality, dependable vibration test system for as little as $1075, including amplifier and shaker.

The MB Vibramatic system, which uses a unique miniature vibration exciter, is produced in 3 ranges: a 25 lb. force system priced at $1075; a 35 lb. force system at $1350; and a 50 lb. force system at $1750. Acceleration rating of all models is 100 g; frequency range is over 10,000 cps.

The Vibramatic System features simplicity of design and ease of operation. It is manufactured to the high quality standards which are characteristic of the MB line of test equipment. It is suitable for a wide range of industrial applications, including fracture testing, component testing and sub-assembly testing.

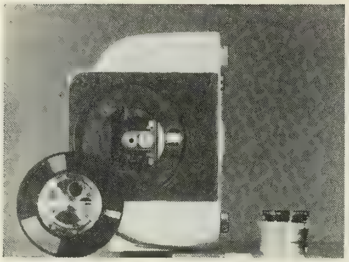
Vibramatic systems can be used for automatic sine and random motion testing by adding suitable readout instrumentation and control accessories.

MB engineers will be glad to discuss your vibration testing problem to determine the suitability of the MB miniature Vibramatic test systems to your particular application. For detailed information and complete specifications on this unique system, write to MB Electronics, 781 Whalley Avenue, New Haven, Connecticut.

Circle No. 14 on Subscriber Service Card

New Product of the Week:

Re-entry Movie Camera



A motion-picture camera that provides a continuous 16mm film record of space vehicle re-entry phenomena despite sudden, extreme changes in light intensity has been developed by D. B. Milliken Co.

The Model DBM-30 is designed to solve the problem caused by rapid incandescence of space vehicle surfaces by bracketing each exposure. Bracketing is achieved by a specially-designed rotary disc shutter that has openings of three sizes—7, 20, and 57 degrees. For each exposure desired, three different exposures are thus registered on successive frames of film.

Circle No. 225 on Subscriber Service Card

Resolver Tracking Bridge

Interstate Electronics Corp. is marketing a dynamic resolver tracking bridge with a balanced high-impedance load in excess of 10 megohms.

The unit has resolution of one second of arc and a nominal RMS accuracy of three seconds of arc. It operates continuously over 360 degrees through unlimited resolver revolutions and provides two digital outputs. Digital resolution is 1:1,296,000.

Circle No. 226 on Subscriber Service Card

DC Electrometer

Washington Technological Associates, Inc., has developed a solid-state direct-coupled electrometer amplifier designed to replace vacuumtube devices used to amplify ion and electron currents as low as $5 \text{ x } 10^{-12}$ amperes.

The Model 10-11 has a response time of less than 80 μsec. and a noise level of less than 350 mv p-p. Temperature stability is 2 mv/°C from —20° to 50°C; output impedance is less than 12 K ohms.

Circle No. 227 on Subscriber Service Card

Gas Cartridge

A squib-operated gas cartridge for storage and rapid release of small quantities of gases has been developed by the Aerospace Div. of Walter Kidde & Co., Inc.

The device features a disc bushing that is ruptured by a piston cutter when a pressurizing squib is fired, thus releasing some 98% of the stored gas in less than 0.05 seconds. The bushing also functions as a safety relief in cases of over-pressurization beyond 6,500 psi. Typical service pressure is 3,000 psi; proof pressure is 5,000 psi. Temperature range is —65° to 160°F.

Design permits adjustment of the body and piston for storage volumes larger or small than the usual 0.65 cu. in.

Circle No. 228 on Subscriber Service Card

High Reliability Stabistor

The Model 1N4362 stabistor, with a failure rate of 0.001% per 1,000 hours, is being marketed by Transitron Electronic Corp.

The device, designed for use as a low-level voltage regulator, is rated at 400 milliwatts and has a gated forward voltage of 1 ma of 0.6 to 0.7v. Minimum-maximum is 0.8 to 0.9v at 100 ma. Inverse current is less than 10 nanoamperes at 50v with a peak inverse breakdown greater than 100v.

Circle No. 229 on Subscriber Service Card

Viewing Microscope

Maser Optics, Inc., is marketing the Model V-301 viewing microscope, a laser system accessory that automatically focuses the laser beam when visually focused on the laser target.

The unit provides visual target observation by means of a precision optical reticle system. Various magnifications are possible and focal lengths can be varied by inter-changeable lenses. The unit can be optionally provided with a beam splitter.

Circle No. 230 on Subscriber Service Card

Angle Measuring Device

Honeywell's Aeronautical Div. is marketing a miniature precision angle measuring device, designed for miniature inertial platform or star tracker gimbal angle readout application. The unit can also be used on rate tables an precision gauging and gear manufacturing equipment.

The device, called Dynagon, offer digital output and unlimited angula freedom. The unit can resolve a circl into more than one million bits wit RMS errors no greater than one ar second. It provides angular rates ranging from more than 180 degrees pe second to less than 0.001 degree pe hour with incremental data available u to a rate of 5,000 cycles per second.

Circle No. 231 on Subscriber Service Card

Miniature Trimmer Capacito

Corning Electronic Component has developed a miniature trimme capacitor, designed to take up minimu board area and allow vertical trimming.

All models are 5/16 in. in diamete and from 0.48 to 0.87 in. high. Th units feature a direct traverse tunin mechanism, giving linear tuning wit capacitance change of 0.4 to 0.6 pF pe turn. DCVW is 750v and dielectri strength is 1,500v. Q factor at 50 m is 500 minimum. Operating temperatur range is —55° to 125°C; temperatur coefficient of capacitance is +25 ±5 parts per million per degree C at 1 mc

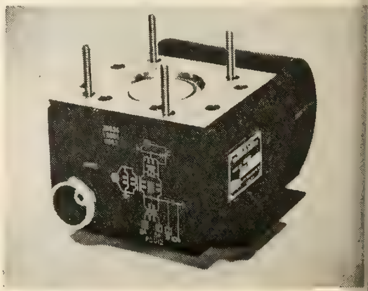
Circle No. 232 on Subscriber Service Card

Pulse Transformer

A high-power direct magnetron-mounted pulse transformer matched t type 4J52 or 6543 magnetrons has bee introduced by Nytronics, Inc.

The unit is rated at 15,000v 15 amperes at a pulse duration of 0.32 to 3. μsec. It provides safe handling o 40,000-v pulses in event of magnetro misfiring.

Input impedance is 50 ohms, outpu impedance is 1,000 ohms. Duty cycle i 0.001 second. Pulse droop is less tha 6% when fired into 1,000-ohm load



Induced voltage of 8,000-v input an 36,000-v output can be withstood fo short periods of time.

Circle No. 233 on Subscriber Service Card

Miniature Osciducer

Solid State Electronics Corp., has developed the Model OS-1000 osciducer, a miniature pressure-to-frequency converter.

The units of the system may be mounted separately and require three connections for operations: 28v dc at 2 milliamperes, ground and the output. A low-impedance output is provided to isolate the oscillator from external loading.

The units can be supplied for all IRIG channels. Frequency deviation is nominally ±7.5% of center frequency. Diaphragm and flush-type transducers are available from 5 to 5,000 psi differential, absolute or gage. The unit will withstand 2,000 g's of shock for a duration of 7 milliseconds; vibration of 60 g's, 0 to 2,000 cps; and acceleration of 3,000 g's.

Circle No. 234 on Subscriber Service Card

Resolver-Synchro Bridge

North Atlantic Industries, Inc., has developed an instrument that tests three-wire synchros and four-wire resolvers with a single instrument.

The Model RSB-570 bridge can determine resolver and synchro accuracy to two seconds of arc for any dialed-in angle. Angular readout is a decimal display providing 0.0001 degree resolution and accuracy of 0.0005 degree over a 359.9999 degree operating range. The device accepts any synchro or resolver voltage to 0.35f, where f is the operating frequency within the 50 to 10,000 cps band.

Circle No. 235 on Subscriber Service Card

Silicon Rectifier

International Rectifier Corp. has developed a plug-in silicon rectifier, designed to replace mercury vapor rectifier tubes.

The Model ST-11 is rated at 7,500v PRV and 5,300v maximum RMS. Maximum output current is 0.2 amperes average at 75°C. Operating temperature range is −40 to 140°C. Units are equipped with tube base to allow direct insertion into existing tube socket.

Circle No. 236 on Subscriber Service Card

Speed Control Unit

Globe Industries, Inc., is marketing a solid-state speed control device, which maintains a synchronous motor speed to ±1% from −55° to 75°C, 22 to 32v dc, and within 0.5% in a constant environment. Speeds from 3,600 to 24,000 rpm are available.

The frequency-controlled unit makes it possible to operate hysteresis synchronous ac motors on dc power. The unit meets MIL-E-5272 specifications. Reverse polarity protection, transient voltage protection and radio noise filtering are available.

Circle No. 237 on Subscriber Service Card

Bandpass Coaxial Filter

E & M Laboratories has available a series of narrowband bandpass coaxial filters designed to pass a limited signal range, rejecting all signals outside the band.

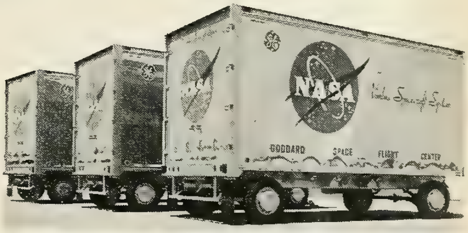
A typical example of the filter is the Model L203CBF, which operates at a center frequency of 800 mc and has a 3-db bandwidth of 20 mc. Insertion loss is 1.5 db maximum. Maximum VSWR is 1.2.

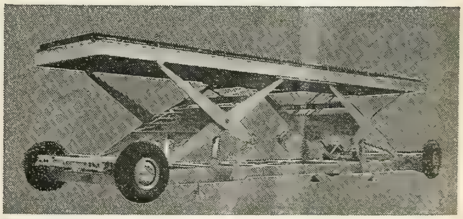
The unit has five resonators to provide the steep skirts necessary to achieve a 60-db minimum rejection at 70 mc bandwidth.

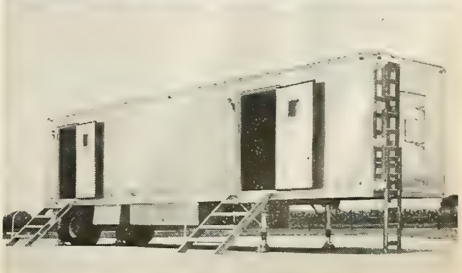
Circle No. 238 on Subscriber Service Card

TRAILERS FOR THE SPACE AGE by DORSEY

Dorsey has built a record of reliability during two decades of handling a variety of defense assignments and the versatility of our engineering and production departments is demonstrated by the current projects illustrated here. For virtually any type of specialized mobile equipment our Special Products Division engineers help prime contractors and defense agencies hold time and cost to a minimum.







TOP: Full trailers to transport NIMBUS spacecraft, built for Goddard Space Flight Center.

CENTER: Elevator-platform trailer designed and built by Dorsey to raise and lower cargo into and out of aircraft. Contract placed by Marshall Space Flight Center.

BOTTOM: Electronics van to house equipment for monitoring acoustical environment around large space vehicles being static fired, built for the Marshall Space Flight Center.

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Circle No. 8 on Subscriber Service Card

Gate Expander Module

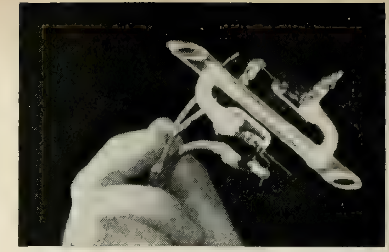
Scientific Data Systems, Inc., is marketing an all-silicon gate expander module that contains 12 two-diode AND gates and 7 gate load resistors. Individual circuits can be used to expand gate structures on other modules to form combinations of AND/OR logic constructions.

The module has an operating range from 0 to 100°C. Noise rejection is said to be twice that of competitive circuits. The unit is available in three models with maximum operating frequencies of 300 kc, 1 mc and 5 mc.

Circle No. 239 on Subscriber Service Card

Miniature Gas Laser

A miniature helium-neon laser that emits a single frequency of visible red light has been developed by Bell Telephone Laboratories.



The unit, with a discharge tube 2 in. long and 0.04 in. in diameter, operates continuously at room temperatures on direct current. Because of its short length, the unit oscillates at only one frequency and is less susceptible to vibration than previous models. This enables the laser to act as a precise measuring instrument. With one of the laser mirrors connected to a positioning device, frequency displacements of less than one-millionth inch can be detected and measured with an oscilloscope.

Active medium of the laser is seven parts He_3 to one part Ne. Input power is 5 milliamps at 470v, about 2 watts dc discharge. Output power is CW ¼ milliwatt from each end. Wavelength is 6,328 Å over a 1,500-mc range centered at 4.73×10^{14} cps.

Circle No. 240 on Subscriber Service Card

Laser Diode Pulser

A laser diode pulser for use with semiconductor junction lasers, such as gallium arsenide and indium arsenide, has been announced by Electro Powerpacs, Inc.

The system has a pulse rise time of less than 20 nanoseconds and provides pulse widths of 0.25, 0.5, 1.0, 2.5, 5 and 10 microseconds, selectable by a switch. Pulse height is continuously variable; repetition rates are controlled by an internal oscillator and are variable from 50 to 5,000 pps. Output impedence is 25 ohms; pulse transformers are available for matching to 0.1 ohm through to 5 ohms. Input is 115v, 60 cps, 50 watts.

Circle No. 241 on Subscriber Service Card

Miniature Pressure Switch

Pall Corp. has developed a subminiature pressure switch with dual circuits that actuate at different pressures.

The device has a brazed pressure-sensing element incorporating a metallic diaphragm. First circuit in the switch closes at pressures below 90 psi, the second at pressures below 50 psi. Electrical rating is 40 ma at 28v dc. Proof pressure is 150 psi.

Circle No. 242 on Subscriber Service Card

Digicator Light Assembly

Digicator light assemblies for readout panels, program boards and other uses are available from Control Switch Div. of Controls Company of America.

A standard strip holds 10 basic sockets with round or square lenses. Lenses rotate in sockets so that strips may be mounted vertically or horizontally. Incandescent 6-, 14- or 28-v or neon midget flange base high-brightness lamps are available.

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AERONAUTICS

Projects have both atmospheric and space applications and work includes preliminary design for configurations, drag estimation, stability and control parameter estimation, validation and detail of design by wind tunnel testing, and participation in trajectory studies to assure capability for the mission. Capability for structural analysis (vibration and flutter) is also needed. MS Degree level of competence is desired.

GUIDANCE AND CONTROL

Projects have both atmospheric and space applications and include analysis in both linear and non-linear systems. Some knowledge of the mathematics of optimum controls is desirable as is familiarity with the use of analog and digital computers in solving guidance and control problems. MS level of capability is desired.

OPERATIONS ANALYSIS

To perform operations analysis of complex military and space systems including trade-off studies on sub-system requirements and costs, leading to assessment of the technical and cost effectiveness of the total system. Knowledge of probability theory and its uses as well as use of digital and analog computers is required. MS level of competence desired.

SYSTEM TEST & INSTRUMENTATION

To conduct tests (including field tests) with special emphasis on telemetry systems. Familiarity with range of techniques and equipments for sounding rockets and probes in a developmental program is required.

PROPULSION

Assignments will include preliminary design of small, high performance solid propulsion systems. Problems include grain, case and nozzle design, specifications writing, and technical participation in developmental subcontracts. Knowledge of the use of analog and/or digital computers is essential as is knowledge of the present state-of-the-art. MS level preferred.

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Temperature Chamber

Delta Design, Inc., is marketing the Model 1064C, a high-precision, low-gradient temperature chamber designed for testing large quantities of electrical or electronic parts.

The unit will accept six test tray modules of two types. One holds up to 48 transistors in sockets that minimize leakage. The other holds up to 70 diodes, resistors or other small components. Both trays are designed to minimize generation of thermal EMF.

Temperature range is —75 to 315°C with higher ranges available. Temperature profile is ±1°C. The programmable temperature control of ±¼°F is maintained over the entire range.

Circle No. 244 on Subscriber Service Card

A/D Converters

Packard Bell Computer Div. of Packard Bell Electronics has added five models to its line of analog/digital converters.

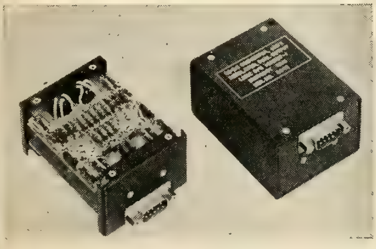
The series ADC20 to 24 offers bit conversion speeds from 1.2 to 4 μsec, word lengths from 10 to 17 bits and accuracy to 0.01%. The models offer synchronous or asynchronous and unipolar or bipolar operation. Other features include precision temperature control of Zener diode (to 0.1°C) for voltage reference stability and isolation of digital output during digitizing by automatic delay of system clock. Packaging is in standard 19-in. rack-mounting cases.

Circle No. 245 on Subscriber Service Card

DC-DC Converter

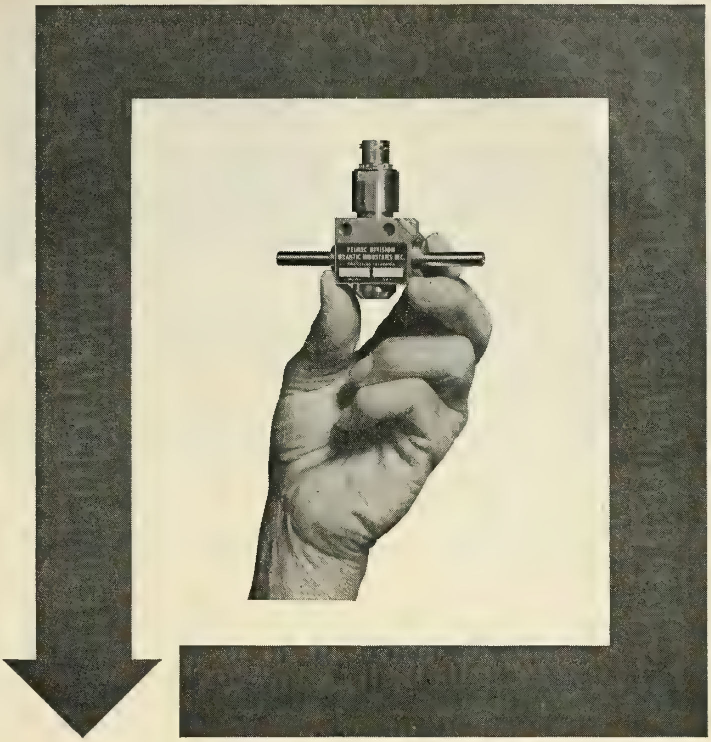
A 28-v dc-dc converter designed as a missile or satellite flight instrument has been introduced by Magnetics Div. of Microdot, Inc.

The Model 1U110 has a battery input range of 22 to 29.5v dc, with up to 3-v peak-to-peak noise, and provides isolated dual outputs of 28v dc at 50 ma each. The unit is protected against both short circuits and reverse polarity.



Other specifications include regulation of ±0.5%, ripple limited to 10 mv peak-to-peak, operation under 20-g vibration, temperatures from —65° to 110°C and shock up to 40 g's.

Circle No. 246 on Subscriber Service Card



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But before you get (pardon the pun) all fired up about the Model 1128, you should see some of the others we've put in orbit. They're available in sizes ¼" to ¾" and larger, in any material, for any environment, pressure-proof to 10,000 psi and beyond. For low-pressure details, drop us a note today.

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names in the news

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PRINCE

Walter Prince: Named director of new Aircraft Modification Center at Baltimore Div. of Martin Co.

James E. Ballmer: Appointed head of Information Systems Research & Development Dept. of Bausch & Lomb, Inc., Rochester, N.Y.

George L. Wiser: Named senior vice president of Sierracin Corp., Burbank, Calif.

Ulrich Kaempf: Appointed European technical adviser for Fairchild Semiconductor Instrumentation, Palo Alto, Calif.

Donald W. Harvey: Appointed manager of industrial relations for the eastern division of Wyman-Gordon Co., Worcester, Mass.

Basil Staros: Appointed director of systems technology at General Applied Science Laboratories, Inc., Westbury, N.Y.

James Jenkins, Jr.: Joined Northrop Nortronics' Systems Support Dept. as administrator of the automation systems section within the Applications Engineering Group, Anaheim, Calif.

A. Vernon Davis: Named manager of public relations for the Fairchild Stratos Corp.'s Aircraft-Missiles Div., Hagerstown, Md.

Dr. Arnold O. Beckman: Elected chairman of the board of trustees of the California Institute of Technology, Pasadena.

Saul Decker: Appointed section head in the CBS Laboratories' Military and Industrial Systems Dept., Stamford, Conn.

Louis C. Prisco: Named marketing manager-communications and displays of the Radio Receptor Div. of General Instrument Corp., Hicksville, N.Y.

Col. Clarence F. Sills (USA Ret.): Named a systems planning representative of Interstate Electronics Corp.'s Washington, D.C. office.

David C. Carmer: Appointed sales manager of Technical Dynamics, Inc., Santa Barbara, Calif.

Lewis J. Cox: Appointed group vice president-industrial/consumer products for Electronic Specialty Co., Los Angeles.

Richard M. Lintner: Named manager of the air defense division of System Development Corp., Santa Monica.

Melvin G. Sulser: Promoted to general sales manager of Denison Engineering Div., American Brake Shoe Co., Columbus, Ohio.

Willis R. Peterson: Appointed chief of the checkout and monitoring systems group in the Systems Support Dept. of Northrop Corp.'s Nortronics Div., Anaheim, Calif.

William L. Roberts: Appointed manager, research and development marketing, for the Data Systems Div. of Litton Industries, Canoga Park, Calif.

Robert W. Ekis: Named assistant to the vice president of engineering at Beech Aircraft Corp., Wichita, Kan.

George M. Underberger: Appointed project manager on the technical staff of E & M Laboratories, Los Angeles.

Peter J. Eelenich: Appointed general manufacturing manager of Detroit operations for Ex-Cell-O Corp.'s Precision Products Group.

Bernard R. Welinski: Named Southern California technical liaison engineer for the Programs Div. of the G.T. Schjeldahl Co., Northfield, Minn.

Winston Riley III: Appointed manager of management science at C-E-I-R Inc.'s research and computing center, Arlington, Va.

Warren J. Nichols: Appointed manager of the Materiel Div. of Space-General Corp., El Monte, Calif.

Joseph W. Barron: Promoted to vice president-administration and planning at General Precision, Inc., Binghamton, N.Y. **Robert J. Campbell** promoted to vice president-marketing of the Link Div.

Wesley S. Melahn: Elected acting president of the System Development Corp., Santa Monica, Calif.

B.J. (Bill) DuPriest: Promoted to manager of the Federal-Mogul Service Div.'s Memphis district.

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—when and where—

JANUARY

146th National Meeting of the American Chemical Society, Denver, Colo., Jan. 19-24.

Aerospace Sciences Meeting, Hotel Astor, New York City, Jan. 20-22.

American Physical Society Conference on Semimetals, Columbia University, New York City, Jan. 21.

American Physical Society Meeting, Statler Hilton Hotel, New York City, Jan. 22-25.

American Mathematical Society 70th Annual Meeting, Miami, Fla., Jan. 23-27.

Second Annual Symposium on Fundamental Phenomena in the Materials Sciences, Sheraton Plaza Hotel, Boston, Jan. 27-28.

Conference on Control and System Optimization, Naval Post Graduate School, Monterey, Calif., Jan. 27-29.

AIAA Solid Propellant Rocket Conference, Palo Alto, Calif., Jan. 29-31, (semi-classified).

American Meteorological Society 44th Annual Meeting, University of California at Los Angeles, Jan. 29-31.

FEBRUARY

American Institute of Chemical Engineering 52nd National Meeting, Hotel Peabody, Memphis, Tenn., Feb. 2-5.

IEEE Winter Power Meeting, Statler-Hilton Hotel, New York City, Feb. 2-7.

International Congress on Documentation and Scientific-Technical Information, Rome, Italy, Feb. 2-11.

International Conference on the Impact of Modern Physics on Materials, Sheraton Hotel, Philadelphia, Feb. 3-7.

IEEE-MIL Fifth Winter Convention on Military Electronics, Ambassador Hotel, Los Angeles, Feb. 5-7.

American College of Radiology National Meeting, Tucson, Ariz., Feb. 5-8.

Institute on Information Storage and Retrieval, sponsored by American University, International Inn, Washington, D.C., Feb. 10-14.

Administration of Government Contracts Course, sponsored by National Defense Education Institute, Washington, D.C., Feb. 10-14.

Golden Gate Metals Conference, San Francisco, Calif., Feb. 13-15.

1964 Annual Meeting and Symposium on Physical Metallurgy of Refractory Metals, sponsored by AIME, New York City, Feb. 16-20.

ASCE Transportation Engineering Conference, Netherland Hilton Hotel, Cincinnati, Ohio, Feb. 17-21.

International Solid State Circuits Conference, sponsored by IEEE and University of Pennsylvania, Sheraton Hotel and University of Pennsylvania, Philadelphia, Feb. 19-21.

9th Scintillation and Semiconductor Counter Symposium, sponsored by IEEE, AEC and NBS, Shoreham Hotel, Washington, D.C., Feb. 26-28.

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State of the Union

TWO REPORTS concerned with the state of the Union were given in Washington last Tuesday. Most of the public attention, of course, was devoted to President Johnson's first State of the Union message to Congress. Of equal import for the industry, however, was a speech delivered that same night to the Harvard Business School Club by Air Force Secretary Eugene Zuckert.

President Johnson strongly reaffirmed the Administration's determination to land a manned expedition on the Moon in this decade. "We must assure our pre-eminence in the peaceful exploration of outer space," the President declared.

Mr. Johnson also asserted that the defense budget which he will send next week to Congress will maintain current U.S. military superiority.

With the national military and space postures as two of his ten major points, President Johnson made it emphatically clear that he will support the areas of greatest interest as strongly as his predecessor.

Although not billed as such, Air Force Secretary Zuckert's speech was a significant preview of Project Forecast, the long-range study aimed at determining the areas of Air Force research and development interest over the next ten years.

It was apparent from what Mr. Zuckert said that the Air Force has taken long strides toward bringing its objectives in line with the policies of Secretary of Defense Robert McNamara and his staff.

The relationship between cost and requirements obviously has been thoroughly studied by the Project Forecast group. Mr. Zuckert did not say so, but Project Forecast took a close look at more than 40 major systems which might be required for Air Force needs in the ten years ahead. Its recommendations for initiation of from three to five of these are carefully documented and are in accord with the cost effectiveness and "building block" technological views of DOD.

Ten areas stressed by Mr. Zuckert were: arms control, crisis management, deterrence, flexibility, controlled response, multiple options, survivability, damage limitation, threshold of negotiation, and termination capability.

"Those are not new concepts in themselves, but they are being brought together and used in a new way for the type of analysis that the Air Force is now making to determine what future forces might be like," Mr. Zuckert pointed out. These ten areas thus provide a clue to what the Air Force is seeking in hardware:

Arms control—which, as described by the Secretary, now is a military requirement. "Military men are concerned with it not because it might make them technologically unemployed, but because it is a necessary part of the defense package," he said. Surveillance obviously was one of the things in mind. Mr. Zuckert also explained that current military planning must provide for forces not dependent upon nuclear testing or any other type of restrictions to which nations may agree.

Crisis management—this was described as the ability to keep even an intense and long-lasting international crisis from exploding into war, or a low-intensity conflict from escalating into higher dimensions of war. "It requires military forces with specific warning and response capabilities," the Secretary said. "It takes carefully tailored military power as well as sound nerves and good intelligence." Reconnaissance is brought to mind by the Secretary's words, as well as a force of long-endurance manned aircraft.

Deterrence—a primary national objective which includes all of the factors that go into the ability to discourage an aggressor, or preclude an attack by the obvious strength to crush it. This includes the capability to respond with something less than all-out nuclear response.

Flexibility—a specific meaning in terms of the organization, equipment and capability for rapid deployment of forces to cover the full range of crisis situations or war requirements. Airlift obviously is of major importance to such an objective, although the Secretary did not mention it in this context.

Controlled response—the ability to adapt the military response to the requirement and retain the initiative. "A choice of options is necessary," Mr. Zuckert declared. Multiple options must be built into the forces in terms of alternate target plans, ability to retarget, multiple delivery systems, selectivity of both strike characteristics and targets, and versatility of employment in both strategic and tactical missions.

Survivability—covers pre-launch protection against nuclear attack, the ability to penetrate defenses, and immunity to sabotage, clandestine operations and capture.

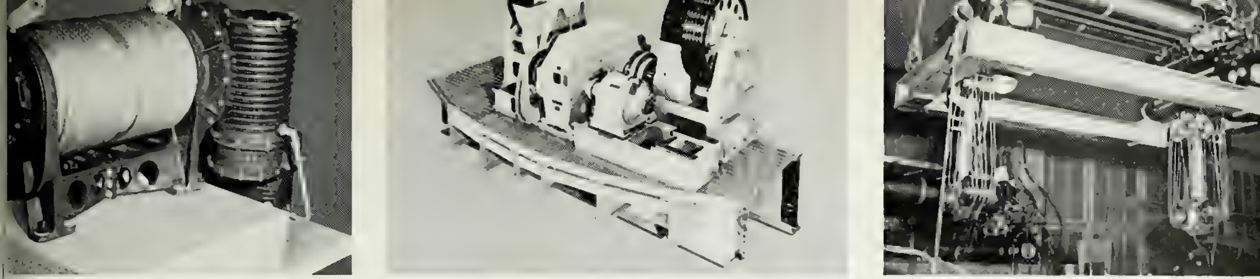
Damage limitation—involves accuracy of targeting to limit damage to the enemy as well as promptly responding defensive systems which can neutralize enemy weapons at safe distances. Also includes accurate assessment of damage.

Threshold of negotiation—reflects determination to stop war at the lowest point of intensity on favorable terms and acknowledgement that destruction of an enemy is not an objective.

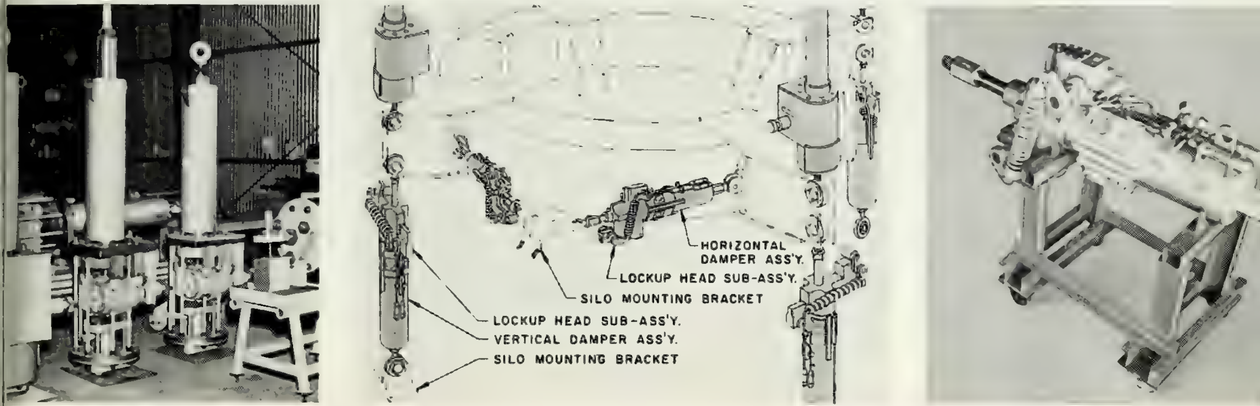
Termination capability—the capability to stop a war, which includes all the other capabilities and requires the ability to counter escalation with increased power at each higher level of intensity.

IT IS APPARENT from the statements of Mr. Johnson and Mr. Zuckert that the Administration is in the process of tailoring a taut, effective Air Force which will be well equipped to assure the future well-being of the state of the Union.

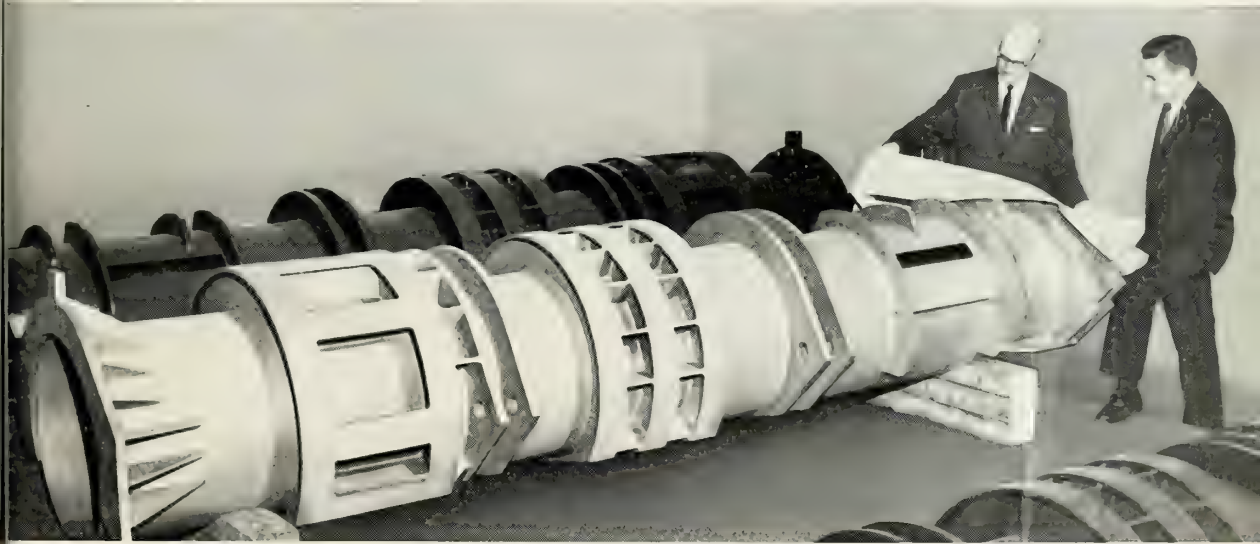
William J. Coughlin



HOISTS—Western supplies these heavy duty hoists for (1) Nike Zeus (2) Atlas and (3) Minuteman missiles.



SHOCK ISOLATION—Vertical and Horizontal damper assemblies of Western's Shock Isolation System for the Titan II.



SPRING CAN ASSEMBLIES—Built by Western as a precision component in the Minuteman missile silo system.

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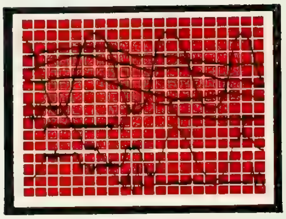

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JANUARY 20, 1964

missiles and rockets

HE WEEKLY OF SPACE SYSTEMS ENGINEERING

First Titan III Static Test Tanks

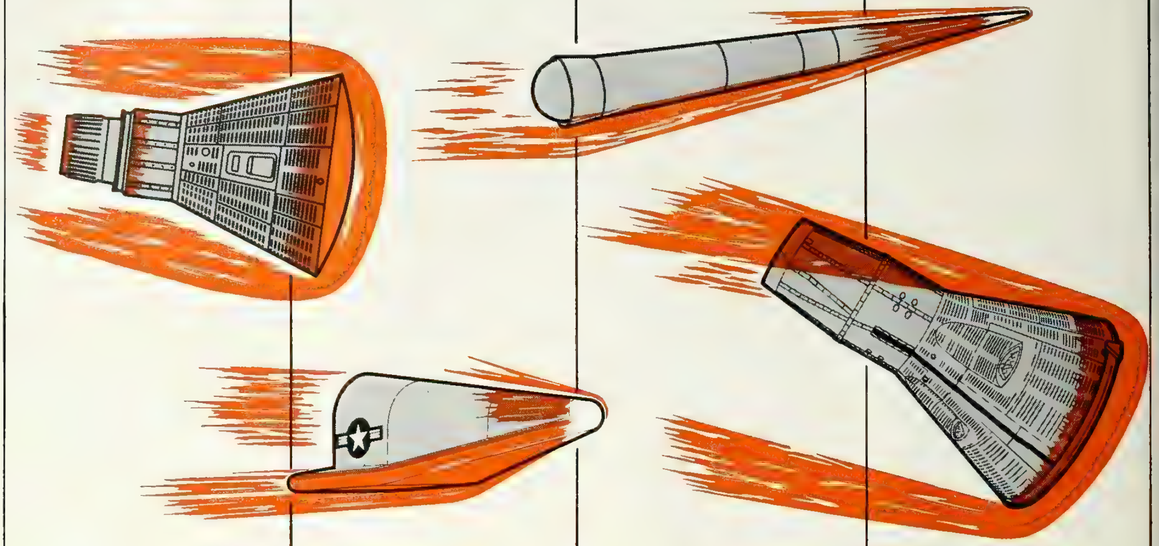
$5.445 Billion Seen Vital for Apollo . . .

DOD Asks $17.2 Billion Authorization . .

Recording System Aids A-ICBM Design .

EARTH ORBITAL REENTRY

Four spacecraft programs, each engineered to explore diverse techniques for earth orbital reentry, are underway at McDonnell.



MERCURY

MERCURY, America's first manned orbital spacecraft, utilizes a non-maneuverable ballistic reentry. After retro-rockets slow the spacecraft to bring it out of orbit, reaction jets position it for reentry. Mercury's ballistic shape maintains alignment with the drag vector as it follows a ballistic path through the atmosphere to drogue chute deployment at 21,000 feet. Final descent to an ocean landing is accomplished with a 63-foot ring-sail parachute.

ASSET

ASSET, an instrumented, unmanned, winged vehicle, will reach speeds of 13,000 miles per hour in sub-orbital flights at altitudes of over 40 miles. This space research program will provide for study of glide reentry technology, refractory materials fabrication experience, and accelerate the development of maneuverable reentry techniques. A parachute landing system enables recovery of vehicle and data package for post flight analysis of test data.

AEROBALLISTIC

AEROBALLISTIC is a word coined to describe the lifting body concepts proven by flights of McDonnell hypersonic missiles from Cape Canaveral in early 1959. The test flights demonstrated precise atmospheric control, the aerodynamic efficiency of an Aeroballistic vehicle and were the first breakthroughs in the design of maneuverable reentry spacecraft. Space missions utilizing an Aeroballistic type vehicle would terminate with a conventional runway landing.

GEMINI

GEMINI is a two-man orbital spacecraft for long duration and rendezvous missions. Upon reentry, the crew will position Gemini's off-set center of gravity with attitude control jets to re-orient the drag vector and create a lift component. This lift will enable the crew to maneuver Gemini to any point in a 28,000 square mile landing area. A paraglider will be deployed in later flights, enabling precise astronaut control of the glide to the landing field.

With MERCURY, ASSET, AEROBALLISTIC and GEMINI Spacecraft, McDonnell is perfecting reentry techniques, shapes, materials and manufacturing processes necessary for the achievement of U. S. leadership in space.

MCDONNELL

- *Mercury and Gemini are being designed and built by McDonnell for NASA under the technical direction of the Manned Spacecraft Center.*
- *Asset is being developed and built under the sponsorship of the Aeronautical Systems Division of the Air Force Systems Command.*
- *Aeroballistic vehicles were developed and tested under contract with the U.S.A.F.*

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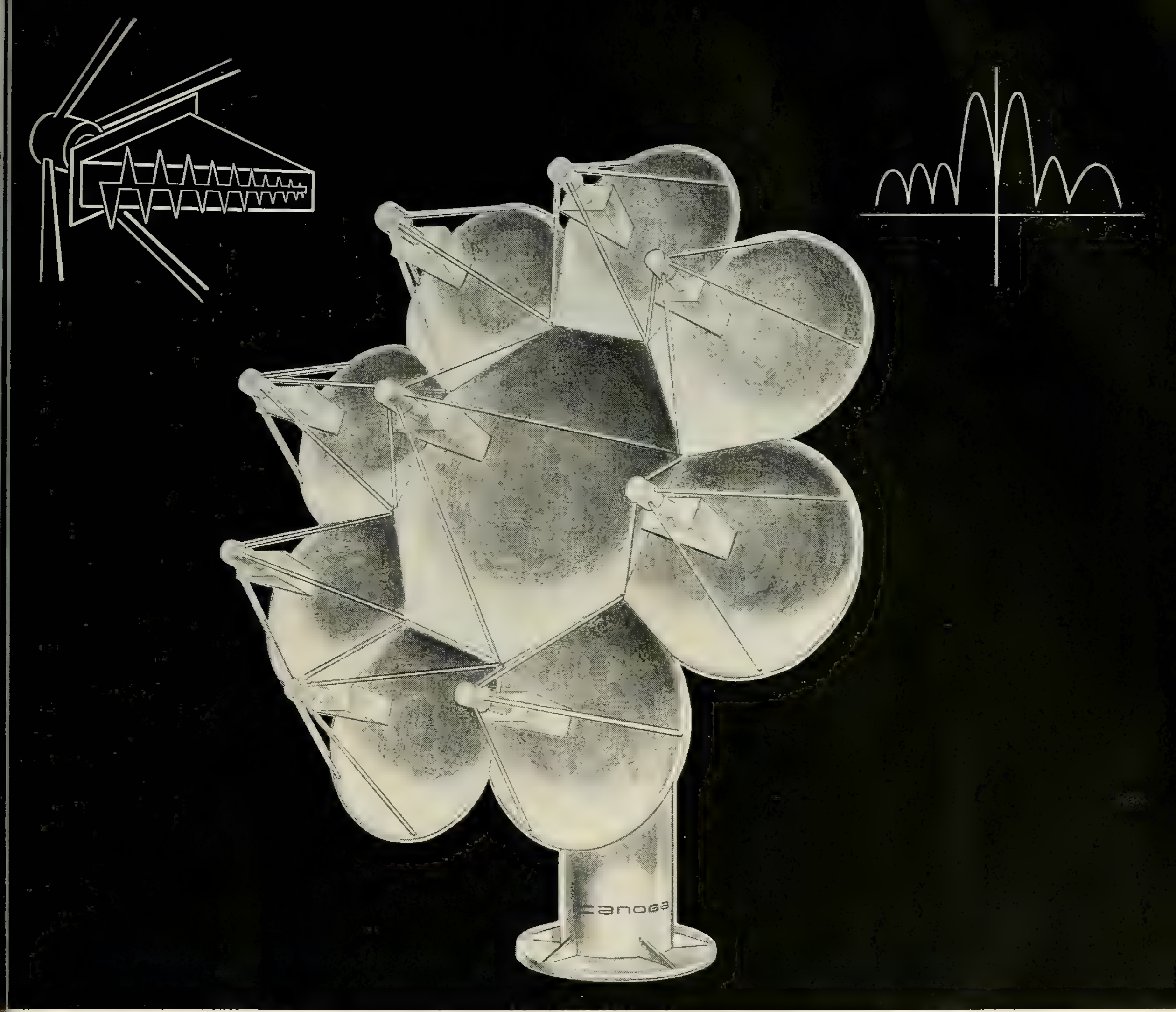

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Canoga currently has under development broadband tracking antennas in the 200-2400 mc and 1000-12000 mc frequency regions. These "Sunflower" monopulse tracking antennas contain nine reflectors, each with its own log periodic feed element of 12:1 frequency bandwidth. Featuring low sidelobes, low antenna noise temperature, high aperture efficiency and relative insensitivity to mechanical tolerances, the Sunflower antenna design is predicated on years of experience in the development of Mercury and Gemini telemetry tracking systems & techniques. It is one of a family of new tracking system developments from Canoga.

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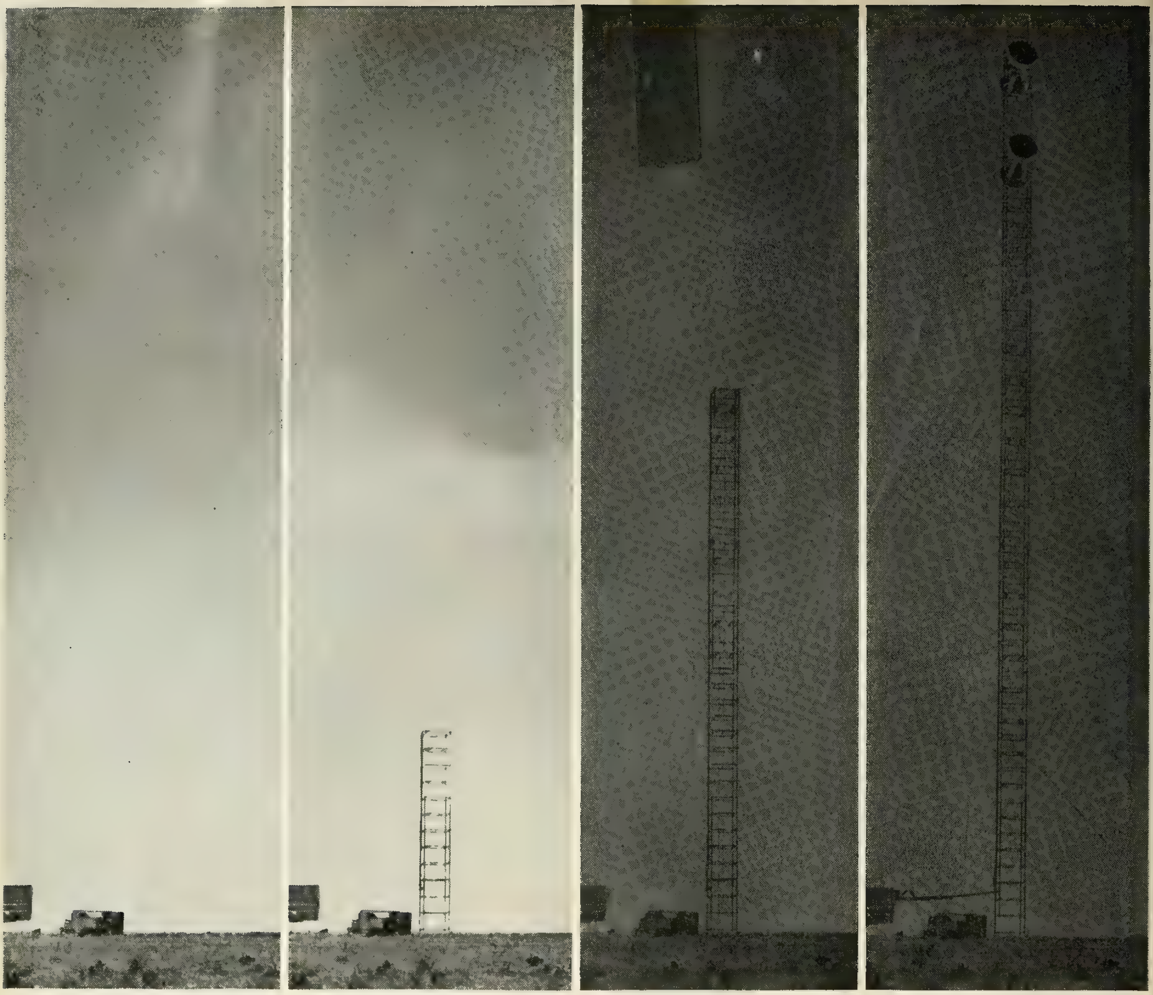

JULY 12—10:02 AM

2:00 PM

8:17 PM

JULY 13—1:57 AM

UP AND OPERATING IN LESS THAN A DAY. Within 21 hours and 55 minutes from the time of the alert, a new microwave tower was up and operating. That was the result of a recent restoration drill by the Bell System, when an announcement at 4:02 AM triggered a realistic test of a "Condition Red" emergency.

The existing tower and buildings at Lenape, Kansas, were reported destroyed. Knocked out were circuits along the whole Kansas City-Wichita microwave route.

As men and equipment rushed to the site, the thousands of circuits were rerouted according to a prearranged plan. In less than an hour service was restored, and within 18 hours after work began, the entire 300-foot tower and all replacement equipment were in operation.

Capable of withstanding 100-mile-an-hour winds, the portable relay tower assembles quickly in sections. And uniquely packaged in weatherproof aluminum cabinets, the electronic equipment comes completely wired for simple installation, and ease of operation.

Each restoration unit has power capacity to relay 7200 telephone conversations simultaneously, or 24 one-way television programs, or combination of calls and TV programs.

The emergency restoration packages were designed by Long Lines Department of A.T.&T. and produced by Western Electric. Located at strategic points across the United States, they can be rushed into service whenever installations are damaged by disasters such as hurricanes and tornadoes, or by warfare or sabotage.

In serving people and the nation with reliable communications, drills such as this pay off in speedier restoration abilities.

BELL TELEPHONE SYSTEM

American Tel. & Tel. Co./Western Electric Co.
Bell Telephone Laboratories/21 Operating Companies

missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING

Volume 14, Number 3 January 20, 1964

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THE COVER

First static test tanks for the Air Force Titan III take shape (right foreground) on assembly line at Martin Co.'s Denver plant. The 10-ft.-dia. tanks are fuel and oxidizer compartments for each of the Titan III core vehicle's two stages. Completion of the tanks confirms production methods for fabricating first Titan III production tanks.

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47,500 copies this issue

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Signal Conditioners

Chart shows 11 basic types and where they may be required.

Magnetic Tape

Chart shows 8 analog and digital recorder/reproducers with support equipment.

Direct Readout

Chart shows 5 recording oscillographs and 33 galvanometers and where they can be used; also support equipment. Write for your chart today. Request CEC Chart DM-37-X10.

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letters

Pro Cape Kennedy

To the Editor:

Any controversy arising over the name change of Cape Canaveral to Cape Kennedy has been caused by a noisy minority of partisan "die-hards," most of whom even now are uninformed concerning the history of the Cape, how it received its name, etc. The great majority of Floridians are greatly honored that the Cape should be named after President Kennedy. It is a shame and a disgrace that these few partisan newcomers to our state and transients should give the impression that the majority of Floridans are opposed to the name change.

It is true that Congressman Gurney's main purpose in life since going to Washington has been to oppose the renaming of the Cape. Perhaps the voters of his district will do something about this in November.

John P. Tanner
Orlando, Fla.

For Private Labs

To the Editor:

The letter from N. A. Renzetti (M/R, Jan. 6, p. 6) requires an answer. After 25 years as a government researcher, Mr. Renzetti opines that both research and advanced development should be done in government laboratories such as the Jet Propulsion Laboratory. He is willing to let private industry do the manufacturing, directed by the government lab.

My 22 years' engineering experience, 15 doing research including two at JPL, didn't make *me* an expert in politics, economics, or defense planning. But logical thinking, plus reading such documents as the Constitution of the United States, plus personal observation of competitive free enterprise in action, convince me that Mr. Renzetti would think differently if he could discard his narrow, self-serving viewpoint.

It boils down to this: A company can get underhanded and unfair, but if it has competition it can't get too inefficient. A government agency can get as corrupt and inefficient as the citizens will tolerate (or even more so if they can be kept ignorant of the true state of affairs).

Knowingly or not, Mr. Renzetti advocates a giant step toward more government control of our lives. I'd rather see us move the other way, because I believe that would reduce my children's chances of living in the U.S.S.A.

James D. Thackrey
Santa Ana, Calif.

Angular Momentum

To the Editor:

In the Letters column of your Dec. 9 issue, Mr. Ecklin asks what is the mechanism which increases the kinetic energy of a mass revolving about a center if the connecting string is made shorter. The answer can be seen if one draws the following picture:

Draw the original orbit and the orbit of shorter radius, then draw the curved path the mass would follow if the mass moves from one orbit to the other. Is the force provided by the string now normal to this path? The component of the string's force which lies along this path is the "mechanism" that increases the velocity of the mass as it moves to the smaller orbit. Since there is no net external torque acting on the system, angular momentum is conserved.

Mr. Ecklin should convince himself that the force of attraction between planets is indeed like the case above. Kepler's third law is derived from the conservation of angular momentum and Newton's law of universal gravitation.

David R. Hollinbeck
Eng. Physics Student
Boulder, Colo.

'Profile Of An Industry' Reprints

IN RESPONSE to widespread reader interest, MISSILES AND ROCKETS *has prepared reprints of the three-part "Profile of an Industry" series by Senior Editor William Beller. Based on recent surveys by U.S. Government agencies and the Stanford Research Institute (under a contract from the Aerospace Industries Association), the articles first appeared in the Oct. 28, Dec. 2 and Dec. 16, 1963, issues of M/R. Together they provide an unprecedented report on the growth of the Missile/Space industry—now the second largest employer in the United States —and its impact on the national economy and technology.*

The twelve-page reprint may be ordered from:

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The Countdown

WASHINGTON

Launch Business Ready to Boom

What could be a spectacular space year for the U.S. will be kicked off by eight launches scheduled for the first quarter. The first will be two-stage *SA-5 Saturn 1* slated for Jan. 29. Following this is another try for a successful reconnaissance of the lunar surface with *Ranger* in the Jan. 30-Feb. 5 period. Other shots scheduled for February are the *Relay* communications satellite from Cape Kennedy on the 21st and the *Echo* passive comsat from Pacific Missile Range on the 23rd. Also due in February-March are the *S-48, S-52* and *S-66* satellites. First-quarter schedule may be topped by first unmanned *Gemini* flight in March, but this could slip.

Who'll Buy MOL Geminis?

Defense Dept. and NASA are threshing out the question of who will buy the *Gemini X* capsules for the *Manned Orbiting Laboratory*. NASA maintains that the Air Force should buy the capsules through the space agency. The Air Force wants to do the buying itself, holding that NASA is not sure enough what it will do with *Gemini* beyond the sixth flight.

Missile Master Follow-on

Army plans to invite bids in February on its TSQ-51 missile fire coordination system to replace Missile Master systems controlling *Nike-Hercules* batteries around major U.S. target areas. Wanted is a more compact, cheaper system than the eight Missile Master installations in operation, which cost $11 million apiece and require about 600 men to operate and maintain them.

Laser Tracking Gets a Push

NASA's Manned Spacecraft Center is asking industry for proposals on a study contract of a high-priority development of laser tracking techniques between Earth and a manned deep-space vehicle or between a satellite and two manned spacecraft. System must be capable of handling two-way telemetry and voice communications, as well as spacecraft-to-ground television. Bids are due by Jan. 22.

Small Business Losing Space Work

Based on net value of awards, small business's share of NASA contracting continues to fall. In Fiscal 1960, small business received 17% of space agency awards. In FY '61, this fell to 15%, in FY '62 to 12%, in FY '63 to 8%.

MSFC Is Top Space Contract Source

Marshall Space Flight Center awarded almost one-third of NASA's FY '63 business with industry. Its contracts totalled $949.8 million—29% of the agency's $3.2 billion. Manned Spacecraft Center was second, with awards of $737.2 million, followed by Western Operations Office ($412.3 million) and Goddard SFC ($303.5 million).

INDUSTRY

Space Radiator Support Discussed

More serious thought is reportedly being given within NASA to backing research into development of space nuclear reactors which can operate in conjunction with gaseous-core reactors to multiply the 2,000-3,000/sec. specific impulses expected of the gaseous systems operating without radiators. Study of radiator design has been soft-pedalled pending some indication that it would be possible to solve major nuclear fuel containment and materials problems. Optimism regarding some of these troubles was expressed last week by United Aircraft Corp. scientists in a New York briefing. UAC's research lab was awarded $460,000 by NASA in December to study the gaseous-core design, an area which previously had Air Force support. UAC recently received a smaller contract aimed specifically at fuel containment.

Ozone Difluoride Progress Reported

Researchers report work with ozone difluoride to render liquid oxygen hypergolic with fuels such as liquid hydrogen, RPL and hydrazine looks very promising and that application probably could be made quite soon. It appeared earlier that the additive might pose severe handling problems, but it now appears that the hazard may be less than that associated with liquid hydrogen.

Second Polaris Trainer Bought

Republic Aviation Corp. has ordered a PC-12 analog computer for a second *Polaris* submarine trainer, to be installed at Pearl Harbor. The earlier $180,000 PC-12 from Electronic Associates, Inc., is operating at Charleston, S. C. It performs very-high-speed on-line computation for closely simulating submarine operation, motion and fire control.

Weightless But Not Effortless

Controversy is continuing over the amount of energy astronauts will use while moving about in zero-gravity environment. Some evidence has been reported that as much, or perhaps even more, energy may be rquired to move about in zero-gas compared to a one-g environment. "It's not just a matter of floating effortlessly from one point to another," one researcher commented.

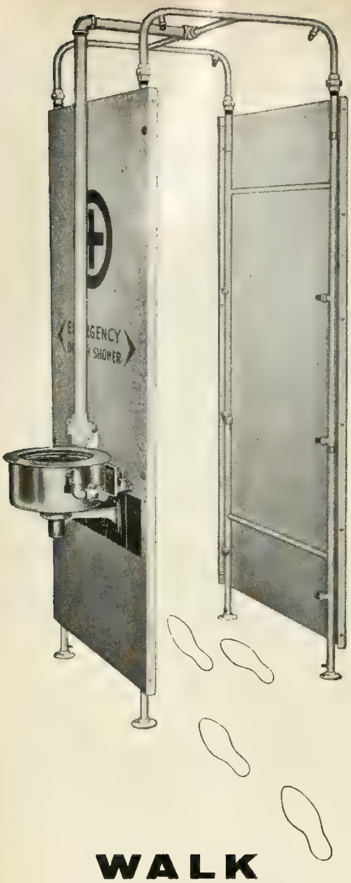
INTERNATIONAL

U.S. Contract for Aussie Jindiviks

The U.S. Navy has signed a $2,250,000 contract for the Australian pilotless jet target aircraft, the *Jindivik.* The award, announced by the Australian Minister for Supply, was arranged through Ling-Temco-Vought, serving as agent for the Australian government. Contract was awarded after a series of Navy evaluation tests at Pt. Mugu. *Jindiviks* will be an integral feature of operational training with guided missiles.

Italian Hot-Water-Boosted Rocket

A low-cost, recoverable rocket powered by hot water has been successfully test-fired by the Societa Trasporti Missilistici of Rome. Designated *"Grillo,"* the 6.6-ft.-long vehicle has a launch velocity of 394 ft./sec. and is propelled by 10.57 quarts of water heated to 330°C by a "rapid heating process of chemical type." The company says it can be launched immediately after command for initiation of the heating process.



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The Missile/Space Week

Engineer Academy Proposed

Establishment of a National Academy of Engineering, analogous to the National Academy of Science, is anticipated within the next six months, according to spokesmen for the Engineers Joint Council.

Eric A. Walker, retiring president of the council, said that the group will ask this session of Congress for the required charter to set up the academy. It will be a step toward the "needed involvement of engineers" in national policy planning. Walker made his statement in Washington Jan. 14 at a press conference closing the EJC's annual meeting.

The academy for the nation's 800,000 engineers is to be patterned after the NAS, which has been working with the EJC in setting up the new body. Like the NAS, the engineering academy would advise the Administration and Congress, when requested, on matters involving engineers.

Speaking for his profession, Walker expressed a wish to be in on the planning stages of national R&D work instead of the design stage.

Membership in the NAE would be limited to those involved in the "successful design of an important engineering work," said Walker. Membership would be open to non-engineers and Walker predicted cross-membership between the two bodies.

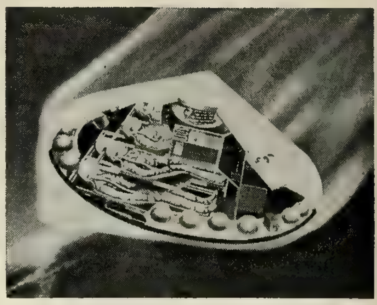
A proposed location for the new Washington academy is a wing on the present NAS building, but Walker stressed that the two bodies would have no organizational ties.

Glenn to Seek Senate Seat

Astronaut John H. Glenn, Jr., apparently has decided to contest incumbent Ohio Sen. Stephen M. Young for the Democratic nomination in the upcoming Senatorial elections in that state. This was the report of a State Democratic spokesman the middle of last week.

Glenn, who has termed himself a political independent in the past, has been wooed as a prospective candidate for public office by both Democrats and Republicans.

The winner of the Young-Glenn contest will face either Republican Representative Robert A. Taft, Jr., or Ohio Secretary of State Ted W. Brown.



Lockheed Mars Mission Re-entry System Proposed

THIS MANEUVERABLE Earth re-entry vehicle conception is the result of a preliminary design for a 1975 Mars Mission done for NASA by Lockheed Missiles and Space Co. The craft could return as many as six astronauts to Earth, after being detached from the main mission module eight hours before the end of a 400-day trip. It would protect its crew in air where temperatures could reach 20,000°C resulting from re-entry speeds up to 65,000 fps. Design was done for NASA's Manned Spacecraft Center, Houston.

DOD Awards Top $6.6M

The Dept. of Defense last week awarded two firms more than $6.6 million in contracts.

Lockheed Missiles & Space Co., Sunnyvale, Calif., received a $4,194,660 Navy contract for the manufacture of test equipment for *Polaris* missiles. Most of the work will be subcontracted to Nortronics Div., Northrop Corp., Anaheim, Calif.

Rocketdyne Div. of North American Aviation, Inc., received a $2.5-million contract from the Air Force for *Atlas* rocket engine propulsion systems. The work will be done at Neosho, Mo., and Canoga Park, Calif.

Anderson Cites Apollo Threat

The Senate Space Committee chairman has suggested that manned lunar landing might be put off until after the 1968-70 peak solar-flare activity period because of the radiation hazard.

Sen. Clinton P. Anderson (D-N.M.) told a Washington, D.C., meeting of the American Institute of Astronautics and Aeronautics "this concern with radiation hazards to space voyagers has been expressed by the Russians as one of the reasons why they are proceeding more slowly on the manned lunar landing."

Anderson quoted from a NASA advisory panel on shielding which last month indicated that *Apollo* shielding might not be sufficient. However, Dr. George M. Knaupf, acting director of Aerospace Medicine, assured M/R that NASA has computed the effects of the worst solar flare in recorded history and feels that *Apollo* astronauts will be protected to within the emergency dose limits set up by the National Academy of Sciences.

NSF to Offer Engineer Grants

A $6-million graduate traineeship program, part of a national effort to accelerate the output of students with advanced degrees in engineering, is being initiated by the National Science Foundation.

According to Dr. Leland J. Haworth, director of NSF, the grants will finance graduate training for approximately 1,200 engineering students during the 1964-65 academic year. The program will provide both stipends for graduate students, primarily in first-year study, and allowances to the academic institutions involved.

Participation in the program will be limited initially to institutions with on-going doctoral programs in at least one field of engineering. Emphasis this year will be placed on institutions able to accommodate additional first-year students on a full-time basis.

Shots of the Week

The Navy launched three *Polaris A2* missiles Jan. 13 in the first operational tests of its new steam ejection system (see p. 23). Only the second of the three shots was a success. The first failed when the second-stage motor failed to ignite; the second veered off-course after 15 sec. of flight and was destroyed by the range safety officer. Launches were all conducted from the U.S.S. Nathan Hale, submerged some 30 mi. off Cape Kennedy.

● The Air Force launched a *Titan II* ICBM Jan. 15 from Cape Kennedy. The successful 5,000-mi. flight terminated in the Ascension Island area of the Atlantic Missile Range. The missile carried a *Gemini* malfunction detection system and incorporated a damping device to counteract the

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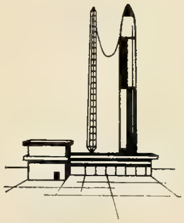

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pogo effect. Also on board the shot was a 117-lb. scientific pod containing a liquid-to-gaseous oxygen converter, data from which was relayed to Earth.

ICBM Dependability Debated

The ICBM dependability dialogue between Presidential aspirant Sen. Barry Goldwater and Defense Secretary Robert S. McNamara appears to be resting with a Goldwater suggestion that a Senate investigation be conducted to either prove or disprove his recent charge that America's ICBM's are "undependable."

McNamara termed the Goldwater charge "completely misleading, politically irresponsible and damaging to the national security."

Shortly after the Arizona senator's initial blast at the ballistic missile program, Cape Kennedy sources released figures to the effect that 70% of U.S. long-range missile tests have been completely successful and that more would have to be termed at least partial successes.

Goldwater mentioned as among the "many factors" making the ICBM unreliable as a retaliatory weapon the possibility that an electromagnetic pulse from a nuclear explosion could render missile guidance systems inoperable (see M/R, Sept. 16, p. 14).

Gemini Booster Test Slips

Test firing of the *Titan II* slated to carry the first *Gemini* into orbit was postponed again last Tuesday. Failure of a gas generator starter cartridge caused the latest delay. An earlier test scheduled for Jan. 9 was scrubbed when trouble was indicated in a pre-valve actuator.

Next attempt is not likely before Jan. 21, and that time appears doubtful because of the scheduled launch that day of NASA's *Relay II*.

Low Bid on MILA Facility

A joint bid of $1,443,289.20 apparently has won the contract to build a frequency control and calibration facility on Merritt Island.

W. V. Pangborn and Co., Inc., Philadelphia, and Lowery Electric, Inc., Coral Gables, Fla., submitted the low bid for the work, which will be jointly funded by NASA and the Air Force.

The facility, which will become part of the Atlantic Missile Range tracking network, will be aimed at support of the *Titan III* and *Saturn V Apollo* programs.

Open House
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Completion of RAC's new research center holds important meaning for the organization itself and for the experienced scientist or engineer seeking a home for his talents and room to grow personally and professionally.

The research center was specifically designed to stimulate the creative intellect and encourage interplay of ideas among RAC's topflight professional staff. The new building also gives RAC the additional space demanded by our rapidly increasing responsibilities.

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The U. S. Army was looking for a solution to a communications problem, and found it in the Burroughs Militarized D825 Modular Data Processing System. With its totally modular concept, the D825 accommodated several special modules. The resulting modular complex became a communications switching system.

The flexible organization that permitted the inclusion of these specially designed modules was the most decisive factor in the Army's choice of the D825. Two other important reasons that influenced their choice were:

1. *Availability.* The D825 organization, with a minimum addition of functionally independent yet interconnected modules, provides useful redundancy so the system cannot be disabled by failure of any module. In actual performance, the D825 has passed MIL Spec environmental tests involving three points: temperature range (0°C—50°C), time of run, and record protection. In addition, the D825 has the ability to automatically recover from power failure without loss of information.

2. *Programming.* The programming features of arbitrarily relocatable programs and data, a comprehensive interrupt system, and simplified storage allocation contributed to the effectiveness of the D825 in the real-time environment of a communications switching system.

The simplicity of the D825's modular organization in meeting the processing requirements of real-time application contributes to system efficiency. For example, the system is designed to permit from one to four computer modules, each with its own thin film scratch pad memory, and from one to ten I/O control modules to fully share the expandable memory of 4,096 to 65,536 words.

The D825's AOSP (Automatic Operating and Scheduling Program) permits unified system balance for real-time response. It enables the system to automatically schedule itself and ensure its own maximum efficiency. In case of any system malfunction, AOSP enables the system to automatically diagnose and bypass the trouble, while the system as a whole continues to run.

For further details, write for our folder, *Burroughs Militarized D825 Modular Data Processing System.* Or let us make arrangements to prove this system's greater throughput on any application. Write to Defense and Space Group, Burroughs Corporation, Paoli, Pa.

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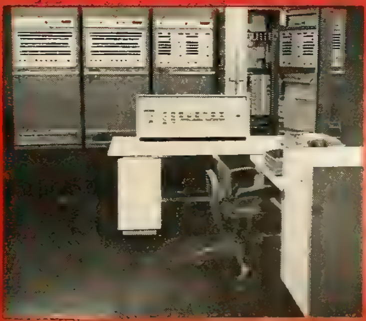


In new funding . . .

$5.445 Billion Vital to Moon Goal

by Hal Taylor

NASA HAS DECLARED officially that Congress must approve $5.445 billion in new appropriations this year or the lunar landing goal will not be met.

Dr. Robert C. Seamans, agency associate administrator, said that a supplemental Fiscal '64 appropriation of $141 million and a new Fiscal '65 budget of $5.304 billion is required if this country is to land a man on the Moon by 1970.

"As far as the manned lunar landing is concerned, we are now cut back to the point that we cannot carry out the program unless we get the full support of Congress, and even then we will have no time to fall back on," Seamans said.

He said that the supplemental appropriation of $110 million for the *Saturn V* and $31 million for the *Apollo* spacecraft would be used to release the job freeze currently in effect among lunar landing program contractors, as well as pay for some needed backup systems for critical items.

The FY '65 request includes $4,438,000,000 for research and development, $281 million for construction of facilities and $641 million for administration operations.

● **Manned programs dominate**—The agency's manned spacecraft activities will—as in FY '64—receive more than two-thirds of the budget, or $3,011,900,000. Budgets for other program offices include $776.9 million for Space Sciences and Applications, $320.3 million for Advanced Research and Technology, $267.9 million for Tracking and Data Acquisition, and $5 million for Technology Utilization and Policy Planning.

If Congress appropriates the full $5.445-billion request, it will still be $225 million below the Fiscal '64 request of $5.7 billion, but $345 million above the amount actually appropriated by Congress.

Seamans said that the Fiscal '64 reduction of $600 million forced a one-year delay in the *Apollo* program. The supplemental request, he continued, would enable NASA to make up six months of the slippage. Approval of the full supplemental and the Fiscal '65 budget would make a lunar landing attempt possible "just a little bit better than the last half of 1969," the NASA official said.

He also admitted that the space agency had originally submitted a total request of $5.97 billion for the next fiscal year, but that President Johnson had trimmed the total by some $668 million.

He added that FY '65 will be the peak funding year for Project *Apollo* and the space agency. He added, however, that if new programs are funded in FY '66, it could make that budget higher than the request for FY '65.

● **New endeavors planned**—Despite the agency budget squeeze, three new programs have been added. They include:

—A new *Advanced Technology Satellite* series which will replace the *Advanced Synchronous Communications Satellite* program. The project calls for the launch of five satellites to test both communications and meteorological equipment at medium and 22,300-mi. synchronous orbits. Tests will also be made of radiation and navigation equipment in the flights slated for 1966-68. One major test will involve studies of a gravity gradient stabilization system for the Department of Defense. Hughes Aircraft Co. is expected to be selected to make a study of the satellite's design.

Proposals from industry on development of the satellites will be requested by NASA from industry as soon as the funds are approved.

—NASA is undertaking a program to use a fluorine/oxygen mixture in

NASA FY '65 BUDGET REQUEST

(In thousands of dollars)

	FY 1964	FY 1964 PROPOSED SUPPLEMENTAL	FY 1965
Research, development and operation	—	—	—
Research and development	$3,909,615	$141,000	$4,382,000
Construction of facilities	673,500	—	281,000
Administrative operations	516,851	—	641,000
Transfers to General Services Administration	34	—	—
TOTAL APPROPRIATIONS	**$5,100,000**	**$141,000**	**$5,304,000**

RESEARCH AND DEVELOPMENT

	FY 1964	FY 1964 PROPOSED SUPPLEMENTAL	FY 1965
MANNED SPACE FLIGHT	**$2,649,800**	**$141,000**	**$3,011,900**
Gemini	383,800	—	308,400
Apollo	2,243,900	141,000	2,677,500
Advanced missions	22,100	—	26,000
Completed missions	—	—	—
SPACE SCIENCE AND APPLICATIONS	**$ 742,500**	—	**$ 776,900**
Geophysics and astronomy	186,200	—	190,200
Lunar and planetary exploration	270,800	—	300,400
Sustaining university program	40,000	—	46,000
Launch vehicle development	125,100	—	128,200
Bioscience	20,600	—	31,000
Meteorological satellites	67,800	—	37,500
Communication satellites	13,500	—	12,600
Advanced techological satellites	18,500	—	31,000
ADVANCED RESEARCH AND TECHNOLOGY	**$ 320,200**	—	**$ 320,300**
Basic research	21,000	—	21,000
Space vehicle systems	49,000	—	38,800
Electronic systems	28,700	—	28,400
Human factor systems	13,200	—	16,200
Nuclear-electric systems	44,700	—	48,100
Nuclear rockets	82,700	—	58,000
Chemical propulsion	45,800	—	59,800
Space power	13,000	—	13,000
Aeronautics	22,100	—	37,000
TRACKING AND DATA ACQUISITION	**$ 210,000**	—	**$ 267,900**
TECHNOLOGY UTILIZATION	**$ 3,500**	—	**$ 5,000**
TOTAL	**$3,926,000**	**$141,000**	**$4,382,000**

CONSTRUCTION OF FACILITIES PROGRAM

MANNED SPACE FLIGHT		
John F. Kennedy Space Center, NASA (Cape Kennedy)	$284,916	$ 91,261
Manned Spacecraft Center (Houston)	35,172	25,166
Marshall Space Flight Center (Huntsville, Ala.)	28,980	15,288
Michoud Plant (New Orleans)	8,688	6,534
Mississippi Test Facility (Pearl River, Miss.)	93,656	61,991
SPACE SCIENCE AND APPLICATIONS		
Goddard Space Flight Center (Greenbelt, Md.)	17,033	1,300
Jet Propulsion Laboratory (Pasadena, Calif.)	2,998	3,714
Wallops Station (Wallops Island, Va.)	505	1,804
ADVANCED RESEARCH AND TECHNOLOGY		
Ames Research Center (Mountain View, Calif.)	11,044	6,081
Electronics Research Center (Location undetermined)	—	10,000
Flight Research Center (Edwards, Calif.)	1,157	—
Langley Research Center (Hampton, Va.)	8,204	4,454
Lewis Research Center (Cleveland)	18,634	810
Nuclear Rocket Development Station (Nevada)	3,240	—
Various locations	148,783	37,597
Facility Planning and Design	10,490	15,000
TOTALS	**$673,500**	**$281,000**

the *Atlas* booster, which it says will increase payload capability by some 30%. Two flight tests of the new fuel mixture will be made using the *Atlas* vehicles left over from the *Mercury* program.

—Backup systems for certain components of the *Saturn V* booster and the *Apollo* spacecraft will be procured if the supplemental appropriation bill is approved. Space agency officials are currently studying a list of 26 possibilities, but it is unlikely that more than five to 10 will be funded. Decision as to which backup systems have the highest priority is imminent.

- **Ups and downs**—In other comments on the budget, Seamans said:

—Space Sciences and Applications—Funding of the heavy observatory satellites will increase while spending on the *Explorer* satellites will decrease. Money for the *Ranger* program will drop to $5 million, but requests for the *Surveyor* and *Lunar Orbiter* spacecraft will show a substantial increase. The budget in this area will also make possible a *Mariner* fly-by of Mars with the *Atlas-Centaur* booster in 1966. The *Pioneer* solar probe program is also slated for substantial funding.

In the communication and meterological satellite areas, the *Advanced Synchronous Satellite* has been dropped, but two more *Nimbus* weather satellites will be developed. Studies of the *Synchronous Meterological Satellite (SMS)* will also continue.

Advanced Research and Technology—Project Fire and the *Micrometeoroid Detection Satellite* projects will continue. Funding for the *SERT* and *SNAP-8* experimental programs will increase slightly. The request for chemical propulsion shows an increase primarily for the M-1 engine and the 260-in. solid motor development program which has been transferred to NASA from DOD.

Manned Spaceflight—The request for Project *Apollo* will be up sharply to $2,677,500,000. Project *Gemini* will drop slightly to $308 million. The space agency, however, is re-programming $73 million from the FY '64 budget for its unmanned projects for the two-man spaceflight series.

The heavier spending is required to overcome problems with the fuel cell and the reaction control system. "POGO" vibration problems in the *Titan II* also increased launch vehicle procurement costs. Some $26 million will be spent on future studies with emphasis on manned space station and lunar base work.

Tracking—Three new tracking stations for Project *Apollo* will be built, including one in Spain. Funding of recovery ships for the three-man spaceflight program is also included in the budget. ■

At $17.2 billion . . .

DOD Authorization Bill May Be History's Biggest

THE DEPARTMENT of Defense has slashed its procurement budget request to less than two thirds of last year's request, and its research, development, test and evaluation to $690 million under what it asked from Congress for FY 1964.

Nevertheless, the total authorization bill introduced on the House floor by Armed Services Committee Chairman Carl Vinson (D-Ga.) amounts to $17.2 billion, believed to be the largest single authorization bill ever to be considered by Congress.

DOD is asking $10.6 billion for procurement of missiles, aircraft and ships, and $6.6 billion for research, development, test and evaluation. Last year's procurement request was for $16.7 billion, which finally resulted in Congressional appropriations of $15.7 billion. RDT&E request was $7.3 billion, which Congress eventually trimmed to $6.9 billion.

This is how the Fiscal 1965 budget breaks down:

—Air Force—DOD is asking $1,730,000,000 for missiles, and $3,663,000,000 for aircraft. It also asks $3,205,000,000 for RDT&E.

—Army—The service asks $282,600,000 for missiles, $443,600,000 for aircraft, and $1,397,000,000 for RDT&E.

—Navy—DOD seeks $660,100,000 for missiles, and $1,854,900,000 for Navy and Marine aircraft. The Marine missile request is $13,100,000. Navy and Marine Corps RDT&E is $1,451,000,000, and the naval vessel request is $1,966,000,000.

—Defense Agencies—For research, development, test and evaluation, DOD requests $519,000,000.

This brings the total missile request to almost $2.7 billion, and the total aircraft request is $5.96 billion.

- **To work**—Hearings will begin Monday, Jan. 27, on the defense bill, with Secretary of Defense Robert S. McNamara as the first witness in closed door hearings.

This marks the first year that the Armed Services Committee will consider research and development other than for ships, missiles and aircraft in the defense budget. In previous years, the remainder of R&D was subject only to the scrutiny of the appropriations committees. This additional research and development, which last year amounted to a little over half the R&D budget, includes space programs. DOD's space budget for FY 1965 is estimated at about $1.7 billion (M/R, Jan. 13, p. 15).

In view of this added responsibility, the House Armed Services Committee last year created a new subcommittee on R&D, chaired by Rep. Melvin Price (D-Ill.). This group met in closed hearings several times a week for several months last session to familiarize itself with the programs of the three services.

Chairman Vinson, in presenting the new bill to Congress, said he was "satisfied that the Department of Defense has made every effort to ask for authorizations for only what they consider to be essential items. However, the Committee on Armed Services will go over each of the items very carefully." He added that "we will have to be convinced that every dollar is justified."

The House Armed Services and Defense Appropriations subcommittees are currently holding hearings on reprogramming actions within the Department of Defense. ■

Comparative FY '64 and '65 Figures

(in millions)

	FY '65 request	FY '64 request	Actual FY '64 appropriation
Procurement of missiles, ships and aircraft	$10,613	$16,724	$15,760
Research, development, test and evaluation	6,572	7,262	6,914

During 1965-70 . . .

U.S., Canada To Launch 4 Satellites

Series to study upper atmosphere during solar-cycle maximum and minimum; to use Alouette and ISIS satellites

CANADA AND THE U.S. have signed an agreement calling for the launch of four new satellites in the 1965-70 period.

Canada will design and develop the *ISIS* (*International Satellites for Ionospheric Studies*). The series will include *Alouette B* and *ISIS A, B* and *C*.

In addition, Canada's Defense Research Board will provide the basic topside sounder experiment, which will study the upper atmosphere, and will operate at least one ground station.

The U.S. representative, NASA, will provide four boosters for the program and will launch the satellites. It will also launch up to five sounding rockets to test components and subsystems.

Basic objective of the satellite series is a comprehensive study of the upper atmosphere from the solar-cycle minimum in 1965 to its maximum in 1970.

- **Alouettes**—*Alouette B* will carry experiments designed to continue the work of *Alouette I*, launched by NASA in September, 1962.

Alouette I contained four experiments: a fixed-frequency device for sounding or charting the ionosphere from above; instruments to measure cosmic noise; equipment to investigate upper-atmosphere radio "signals" initiated by lightning strokes; and several energetic-particle detectors.

Alouette B will resemble its predecessor in size, shape and 320-lb. weight. It will repeat *Alouette I's* experiments as it passes over the Earth's poles in an elliptical orbit varying in altitude from 460 to about 1,600 statute mi. *Alouette I* is in a circular orbit over the poles at 630-mi. altitude. Along with *Alouette B*, NASA will launch a *Direct Measurement Explorer* satellite similar to *Explorer VIII*.

Components similar to those carried in *Alouette I* will be redesigned to conform with the increased altitude of the new satellite, and the telemetry transmitter power will be increased. A magnetometer and solar-aspect sensor will be included to provide continuous information on the satellite's orientation.

Alouette B will also differ from its predecessor by carrying a fifth experiment, an electron probe designed by NASA to determine the temperature of electrons in the vicinity of the orbiting satellite. The short, antenna-like probes on *Alouette B* will relay the temperature and data from the other four experiments, to 13 worldwide ground stations.

Space for this fifth experiment was provided by redesigning the nickel-cadmium batteries employed in *Alouette I* to permit employment of fewer battery units. These batteries will be charged by 6,500 solar cells, more resistant to radiation than those now in use and protected against micrometeorites.

The launch, by a *Thor-Agena* from the Pacific Missile Range, is slated for the first half of 1965.

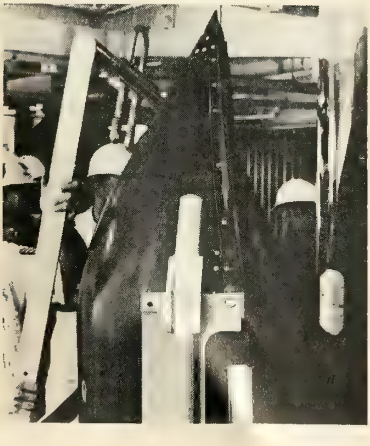
- **ISIS outlook**—Plans for the *ISIS* satellite series are still in the preliminary stages. *ISIS A* will be a completely new spacecraft but will carry experiments similar to those in *Alouette B*. Additional experiments such as electron and ion probes, which measure the temperature and densities of the hydrogen, helium and oxygen present at satellite altitudes, and an ion-mass spectrometer to confirm the identification of the individual ions, probably will be included.

Firm specifications for *ISIS A* have yet to be determined. Design will begin in January with launching of the satellite planned tentatively for 1967.

Because the *ISIS B* spacecraft will be planned as an "even more experimental" satellite than its predecessors, its experiments and design will depend on data returned from *Alouette II* and the *Direct Measurement Explorer*. Design and launch time have not yet been discussed in specific terms.

The design phase of *ISIS C*, which will closely resemble *ISIS A*, is expected to begin in 1966 for a launching tentatively set for early 1969 during the maximum phase of the sunspot cycle.

Associated with Canada's Defense Research Telecommunications Establishment throughout the program will be research laboratories in the U.S., the United Kingdom, and other countries. NASA's Office of Space Science and Applications will have overall responsibility for U.S. participation in the program. Goddard Space Flight Center will participate in data analysis and carry out the companion sounding rocket experiments and the *Direct Measurement Explorer* project. ■



Atlas Decoy Pods Shown

FIRST PHOTO of a U.S. ICBM carrying penetration aids. Philco/Aeronutronic, which developed and is building the decoys for the Air Force, says the devices make it impossible to tell a real warhead from the accompanying set of decoys. The decoys are carried by the Atlas F and Titans I and II.

New details disclosed . . .

ASSET Will Become More Sophisticated In X-20 Substitute Role

by David C. Breasted

THE AIR FORCE plans a March launching in its *ASSET* program, which has gained new attention and stature since the demise of the *X-20* last month.

Spokesmen said last week that the current six-shot program probably will end in January, 1965. While liberal with additional details of the present *ASSET* vehicles and test objectives, sources in the Air Force and Directorate of Defense Research and Engineering remained mum on what ideas they are entertaining for the "expanded" *ASSET* program for investigating less expensively some of the phenomena *X-20* was meant to probe.

It is apparent, however, that both Air Force and DDR&E favor development of a new and varied family of *ASSET* vehicles rather than doctoring and extending the life of the current 6-ft. model.

In exploring maneuverability and other technological problems of high lift-over-drag follow-on vehicles, the Air Force would like to widen its knowledge of high temperature-resistant bearings and activation devices, skin friction, and boundary layer phenomena, among other things.

The March shot of *ASSET* (Aerothermodynamic/elastic Structural Systems Environmental Tests) will send an 1,140-lb. vehicle in a 196,000-ft. arc from Cape Kennedy more than 1,000 mi., with a planned re-entry velocity starting at 18,000 feet per second.

- **Progression**—If all goes well, a third shot planned for May will approach the maximum series velocity of 19,500 fps. The sixth shot is planned for this velocity.

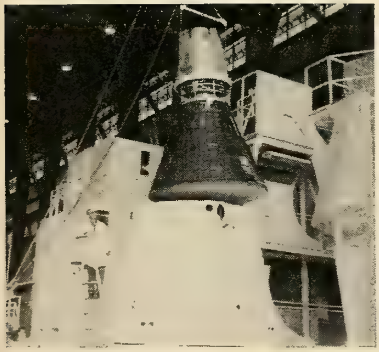
ASSET has an improved floatation system for recovery. It was developed after the otherwise successful first vehicle sank after impact in September.

Temperatures will vary from about 4,000°F at the zirconium-rod nose caps used in five of the vehicles to about 1,000°F at the titanium aft bulkheads. Three layers of insulation between the exotic-metal bottom and the titanium floor, plus additional inside layers, will keep the interior temperature at about 160 degrees. A sixth craft during the series will employ a coated tungsten nose cap.

Four *ASV* (Aerothermodynamic Structural Vehicles) recoverable craft will be used. The remaining two will be *AEV's* (Aerothermodynamic Elastic Vehicles), differing in having two experimental movable panels on the bottom. One will be a 1x2-ft. spring-activated columbium flap in the trailing edge which will oscillate at 25 cycles through 2 degrees.

The other is a flutter panel of very thin refractory material mounted forward of the "break" on the bottom to test phenomena which will be encountered by thin-skinned vehicles such as *Aerospace Plane.*

The *AEV's* are slated for the fourth and fifth firings, tentatively scheduled for July and September. Little is known of flutter phenomena during re-entry, and conditions cannot be duplicated in wind tunnels, according to Air Force spokesmen. ■



Gemini and Adapter At Cape Kennedy

GEMINI SPACECRAFT #1 is raised into position above adapter section in Hanger "AF" at Cape Kennedy. Structure at right will provide white-room atmosphere for spacecraft checkout.

AF Pressed to Define MOL Experiments

DEFENSE DEPT. research and engineering officials have given detailed thinking on the *Manned Orbiting Laboratory* a clean bill of health. They have left it largely up to the Air Force when and how to proceed with study contracts.

But the Air Force is sweating under relentless pressure to define within the nth tolerance what experiments it proposes to put aboard *MOL* and why. Delay in awarding $1 million in study contracts is partly due to studied AF deliberation in anteing up on the long-sought manned military space proposal.

The laboratory concept is moving toward a "plug-in" approach while avoiding imposition of undesirable constraints on the operational, scientific, and biological monitoring experiments under study. From precise definition of experimentation will follow determination of such requirements as compartmentalization, stabilization, and different configurations for different flights, one top official stressed.

"I would like to see *MOL* stimulate the scientific imagination of the country—ideas pour in. I don't mean crackpot ideas," he said.

The official cited several cost reduction areas in which the Air Force *Gemini X* capsules will differ from NASA *Gemini* versions over-designed for possible lunar probes. Among these were:

Fuel cells: Gemini X will require fewer of the costly cells, which are "not out of the woods yet by any means."

Computer: "Very expensive" and more than the return vehicle would need.

Flight control: "Adaption of the *Mercury* system might do just fine."

The general idea, he said, is to "take out as much as possible" rather than redesign.

As top contractors . . .

NAA, McDonnell Repeat at NASA

NORTH AMERICAN Aviation, Inc., retained its ranking as NASA's biggest industrial contractor during Fiscal 1963.

The firm, with prime contracts for the command and service modules of the *Apollo* spacecraft and part of the *Saturn V* booster, received $525,806,000 in direct awards from the space agency. Its total represented 23.2% of NASA's business with industry in FY '63.

McDonnell Aircraft Corp., with contracts for the development of the *Mercury* and *Gemini* capsules, also retained its number two rating with total awards of $193,052,000.

Aerojet-General Corp., with contracts worth $160,483,000, and Douglas Aircraft Co., Inc., with $133,006,000, were third and fourth, respectively, in the list of the agency's top 100 contractors.

One major switch saw the Boeing Co. jump from 13th in FY '62 to sixth in FY '63. The firm received $101,031,000, primarily because of its role as prime contractor for the *Saturn V*.

Other highlights of NASA's annual procurement report for FY '63 include:

—In net value of awards, cost-plus-fixed-fee contracts accounted for 77% of NASA's total awards. Seventy percent of such contracts received a profit fee ranging from 6 to 6.99%. Twenty-three percent received profits running from 7 to 7.99%.

—California was again the leading state sharing in NASA procurement with total awards of $1,099,000,000. The second ranking state, Missouri, received only $197 million.

NASA LIST OF FY 1963 100 TOP PRIME CONTRACTORS

	CONTRACTOR	RANK IN FY 1962	NET VALUE OF AWARDS	
			THOUSANDS OF DOLLARS	PERCENT OF TOTAL AWARDS TO BUSINESS
	TOTAL AWARDS TO BUSINESS		$2,261,600	100.0
1.	North American Aviation, Inc.	1	525,806	23.2
2.	McDonnell Aircraft Corp.	2	193,052	8.5
3.	Aerojet-General Corp.	4	160,483	7.1
4.	Douglas Aircraft Co., Inc.	3	133,006	5.9
5.	General Dynamics Corp.	7	103,118	4.6
6.	Boeing Company	13	101,031	4.5
7.	Chrysler Corp.	6	75,416	3.3
8.	General Electric Co.	10	52,957	2.3
9.	United Aircraft Co.	5	48,879	2.2
10.	Grumman Aircraft Engineering Corp.	9	48,197	2.1
11.	Radio Corporation of America	11	42,169	1.9
12.	International Business Machines Corp.	15	36,135	1.6
13.	Bendix Corp.	12	32,517	1.4
14.	Space Technology Laboratories, Inc.	14	32,510	1.4
15.	Ling-Temco-Vought, Inc.	8	26,722	1.2
16.	Brown Engineering Company	16	24,104	1.1
17.	Lockheed Aircraft Corp.	21	23,656	1.0
18.	Hughes Aircraft Co.	18	18,317	0.8
19.	Mason-Rust	62	16,406	0.7
20.	Hayes International Corp.	17	15,433	0.7
21.	Philco Corp.	26	14,864	0.7
22.	Union Carbide Corp.	25	12,747	0.6
23.	Lear-Siegler, Inc.	***	11,582	0.5
24.	General Motors Corp.	59	10,170	0.4
25.	Republic Aviation Corp.	20	9,273	0.4
26.	Universal Marion Corp.	***	8,999	0.4
27.	Martin Marietta Corp.	47	7,173	0.3
28.	Raytheon Co.	***	7,141	0.3
29.	Norair Engineering Corp.	100	7,072	0.3
30.	Electro-Mechanical Research, Inc.	79	6,821	0.3
31.	Bellcomm Inc.	***	6,355	0.3
32.	Fairchild Stratos Corp.	***	6,241	0.3
33.	Catalytic Construction Co.	***	5,850	0.3
34.	Kollsman Instrument Corp.	70	5,061	0.2
35.	Radiation Inc.	37	4,874	0.2
36.	Collins Radio Company	31	4,599	0.2
37.	Federal Mogul Bower Bearings, Inc.	46	4,281	0.2
38.	Air Products & Chemicals Inc.	35	3,893	0.2
39.	Westinghouse Electric Corp.	34	3,820	0.2
40.	Ampex Corp.	44	3,765	0.2
41.	Avco Corp.	57	3 700	0.2
42.	Thiokol Chemical Corp.	88	3,690	0.2
43.	Telecomputing Corp.	82	3,632	0.2
44.	Sullivan Long & Hagerty	***	3,515	0.2
45.	Documentation Inc.	67	3,416	0.2
46.	Spaco Inc.	56	3,374	0.1
47.	Sperry Rand Corp.	41	3,210	0.1
48.	Minneapolis-Honeywell Regulator Co.	23	3,175	0.1
49.	Bell Aerospace Corp.	***	3,096	0.1
50.	Motorola Inc.	22	3,057	0.1
51.	Roediger Construction Inc.	***	3,000	0.1
52.	Algernon Blair, Inc.	52	2,952	0.1
53.	Garrett Corp.	***	2,937	0.1
54.	Packard Bell Electronics Corp.	24	2,777	0.1
55.	Swenson, Carl N. Co.	***	2,743	0.1
56.	American Telephone & Telegraph Co.	42	2,697	0.1
57.	Calumet & Hecla, Inc.	33	2,687	0.1
58.	Pearce & Gresham Co.	***	2,673	0.1
59.	Ball Bros. Research Corp.	39	2,593	0.1
60.	Thompson-Ramo-Wooldridge Inc.	30	2,556	0.1
61.	Control Data Corp.	***	2,457	0.1
62.	Piracci Construction Co. Inc.	***	2,422	0.1
63.	Doyle & Russell Inc.	45	2,273	0.1
64.	Noble Co.	95	2,227	0.1
65.	Vitro Corp of America	50	2,187	0.1
66.	Kaiser Engineers	***	2,144	0.1
67.	Electronic Associates, Inc.	69	2,045	0.1
68.	Northrop Corp.	63	1,958	0.1
69.	Western Electric Inc.	19	1,930	0.1
70.	Sverdrup & Parcel & Associates, Inc.	53	1,928	0.1
71.	Canoga Electronics Corp.	***	1,897	0.1
72.	Consolidated Electrodynamics Corp.	73	1,764	0.1
73.	Spacecraft, Inc.	***	1,762	0.1
74.	Wyle Laboratories	***	1,696	0.1
75.	Scientific Data Systems	***	1,639	0.1
76.	American Machine & Foundry Co.	***	1,617	0.1
77.	Beech Aircraft Corp.	***	1,586	0.1
78.	Consolidated Systems Corp.	48	1,520	0.1
79.	Textron, Inc.	***	1,504	0.1
80.	Management Services Inc.	43	1,496	0.1
81.	Rohr Corp.	71	1,473	0.1
82.	Space-General Corp.	83	1,448	0.1
83.	Electronic Communications Inc.	***	1,440	0.1
84.	Electro-Optical Systems, Inc.	87	1,397	0.1
85.	Textron Electronics Inc.	***	1,336	0.1
86.	Pacific Gas & Electric Co.	***	1,320	0.1
87.	Federal Service Inc.	***	1,320	0.1
88.	Ryan Aeronautical Co.	***	1,303	0.1
89.	International Telephone & Telegraph Corp.	40	1,302	0.1
90.	Progressive Welder & Machine Co.	58	1,266	0.1
91.	Computer Control Corp.	***	1,253	0.1
92.	Bechtel Corp.	78	1,249	0.1
93.	Alco Products Inc.	***	1,243	0.1
94.	Schrimsher J. T. Construction Co.	66	1,243	0.1
95.	California Computer Products Inc.	92	1,230	0.1
96.	Minnesota Mining & Mfg. Co.	84	1,186	0.1
97.	Gulton Industries Inc.	98	1,174	0.1
98.	Quiller Construction Co., Inc.	***	1,164	0.1
99.	McDonough Construction Co.	***	1,151	0.1
100.	Geophysics Corp of America	68	1,148	0.1
	Other		281,927	11.5

Debate on landing timing . . .

NASA Near Decision on Whether To Impact or Fly By Mars in '66

by Heather M. David

NASA OFFICIALS will announce a decision next month on whether the *Mariner B* spacecraft will impact or fly by Mars in 1966.

Back of the decision is some heavyweight wrestling among space biology experts and hardware engineers on the proper timing of a Mars landing. All, however, now agree that this planet is the major goal of the search for extraterrestrial life, since temperature readings of *Mariner II* have virtually ruled out Venus.

These are the factors now under discussion:

—Will it be possible to land a *Mariner* payload of any scientific significance on Mars in view of the now generally accepted estimate of the atmospheric pressure as about 10-20 millibars?

—Is it sure enough at this time that techniques of sterilization will prevent contamination of the planet?

—Should the payload consist of instruments to make physical measurements or should it be a biological experiment to determine whether life exists?

• **Atmosphere**—The announcement by Dr. Gerard Kuiper of the University of Arizona of the 10-millibar density of the Mars atmosphere confirms work done about two years ago by Kaplan, Spinrad and Muench of the Mt. Palomar Observatory.

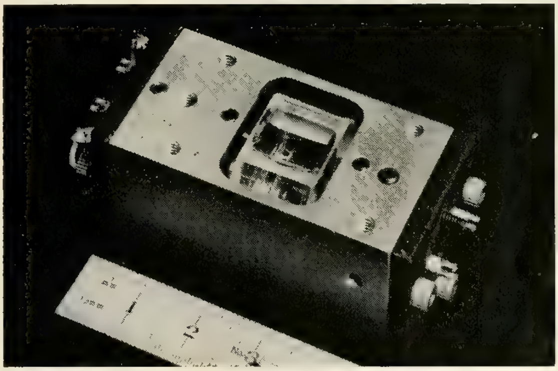
While much of the theoretical work regarding possible types of life on Mars has been done with the assumption of an atmosphere with about 80 millibars' pressure, NASA biologists say the revision does not affect their thinking on this score.

However, the problem of landing a spacecraft with usable instruments is a real one. Much of the weight allotted to experiments must now be used for retrorockets. Apart from making the choice of experiments more difficult, some biologists at a recent Space Biology workshop conference at the University of Rochester fear that retrorockets might either chemically pollute or scorch the area around the landing site and render it useless for biological experimentation.

• **Choice of experiments**—One of the decisions NASA must make next month is whether a biological experiment should be included in the first Mars lander. Space biologists generally are pressing for this—although there are substantial drawbacks.

If the *Mariner* is not sent into orbit around the planet, a landing package will have a limited time—perhaps an hour—to gather data and transmit it to the satellite as it passes the planet. It may be difficult to detect the presence of life in this time.

If the first experiment fails to produce results, it may damage the whole program from a political point of view. A positive answer, however, would greatly enhance the idea ventured by many biologists (M/R, Jan. 6, 1964) that a major probe of Mars should get top national priority. As it now stands, there are no funds for a *Voyager* or modified *Mariner* flight in 1969 in the FY '65 budget.



WOLFTRAP draws soil samples into chamber and culture tubes.

According to NASA exobiologists, these experiments might be ready for *Mariner B* in 1966:

• **Gulliver**—Termed the experiment nearest being ready for flight, Gulliver employs three "sticky strings" which are shot out by bullets, then reeled back, hopefully drawing samples of Martian soil and microorganisms. This material is put into a radioisotopically-tagged culture medium—which incidentally contains nutrient for both L and D (mirror image) amino acids. A radiation counter then is used to detect metabolic products.

Dr. Gilbert V. Levin and Dr. Norman Horwitz, developers of the concept, told the Space Biology conference that there is some chance the nutrient could be dropped directly on the sand rather than bringing the sand to the chamber. This would simplify the system considerably.

• **Multivator**—This instrument, which determines the presence of phosphatase, now measures about 10 in. long and 2 in. in diameter and weighs one pound. Measurement of fluorescence—indicating the presence of phosphatase—is made by a photomultiplier tube and transmitted back to Earth.

The multivator could give an almost instantaneous readout of the presence of phosphatase—essential in living systems for energy transport—and the instrument is considered well along in development. Dr. Joshua Lederberg heads a team of developers at Stanford University.

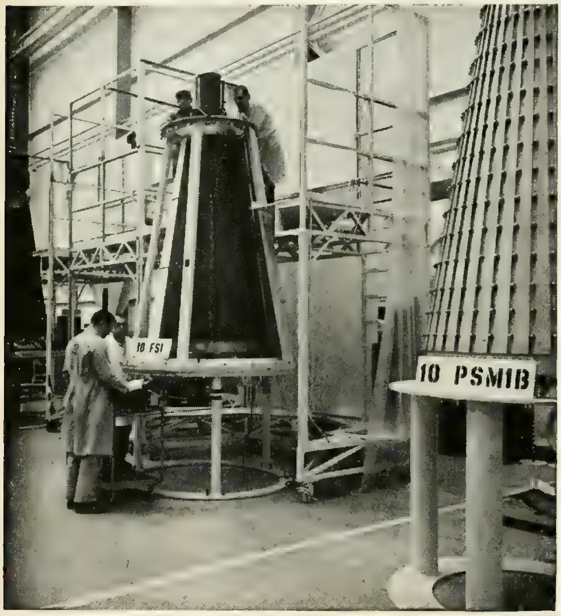
• **Wolftrap**—The device named for its inventor, Professor Wolf Vishniac of the University of Rochester, measures growth by change in acidity and turbidity of the media (see photo). The entire instrument has now been reduced in size to little more than the size of a book of matches. It is in breadboard stage and could be ready by 1966, NASA says. ■

CHALLENGE IN SPACE

FOR SENIOR TECHNICAL SPECIALISTS:

Compact Nuclear Systems to Power Tomorrow's Spaceways

Life support equipment, navigation instrumentation, experimental devices, all things electrical for man's future space flights can bear the imprint of your talent through advanced nuclear work at Atomics International. If you have 5 to 7 years of aerospace hardware experience, an EE, Physics or ME degree, the challenge of nuclear auxiliary power for space lies squarely before you. Join A.I. now in this vitally important work.



Fabrication of SNAP 10A systems at A.I.

Atomics International is a prime contractor for SNAP nuclear reactor systems for the U.S. Atomic Energy Commission. Responsibilities of the company include the entire SNAP 10A and SNAP 2 systems, as well as the reactor for SNAP 8. These power sources are designed to generate from 500 to 35,000 watts of electricity for a one-year period of unattended operation in space. Already several A.I. SNAP reactors have successfully passed their initial ground operating tests.

For the National Aeronautics and Space Administration, A.I. is studying the uses of compact nuclear power sources on the moon. To be determined: what design modifications would fit SNAP 2 and SNAP 10A for powering instruments and communications equipment on the lunar surface? Also, how could SNAP 8 be adapted to the power needs of a manned lunar base? SNAP applications might include lunar communications stations capable of operating for long periods unattended... perhaps a manned lunar experimental laboratory or astronomical observatory.

If you are interested in these and other rewarding challenges of space, the time for action is now. Opportunities now available in Atomics International's SNAP programs and other advanced nuclear work include the following:

SYSTEMS & CONTROL ANALYSIS — Analysis and simulation of complete nuclear power plants to develop reliable, automatic control and instrument systems to analyze reactor kinetics, dynamics, stability, thermal characteristics and reliability.

STRESS ANALYSIS — Provide stress analysis of compact nuclear power plants for space applications including review of all designs with respect to stresses resulting from thermogradients; transients, static loadings, vibrational and shock loadings.

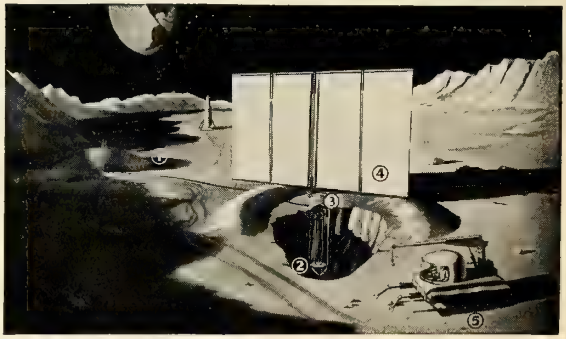
COMPONENT TESTING — Analysis of liquid metal heat transfer components in the SNAP 2/10A systems. Calculations involve knowledge of fluid flow, heat transfer, stress analysis and basic electrical engineering.

ENVIRONMENTAL TESTING — Plan and provide instrumentation for environmental tests of SNAP components and systems primarily for shock, vibration, acceleration, static loading and acoustics.

STRUCTURES — Analyze, investigate and physically test SNAP 2 radiator condensers and test fixtures to determine structural characteristics for launch loads, aerodynamic heating, shock and vibration.

DESIGN — Design high temperature, high reliability nuclear reactor auxiliary systems. Skills required in mechanical design, stress analysis and heat transfer.

Contact: Mr. H. A. Leighton
Personnel Office, Atomics International
8900 De Soto Ave.
Canoga Park, California



Manned moon base illustrated at (1) would receive its power from SNAP reactor (2) beneath lunar surface. (3) shows power conversion units; (4) is radiator to dispose of excess heat. Roving electrical vehicle (5) would use SNAP power to charge its batteries.

All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

ATOMICS INTERNATIONAL
DIVISION OF NORTH AMERICAN AVIATION

Technical Countdown

ELECTRONICS

Japanese Comm. Facility Nears Completion

The new Kashima, Japan, research station for the Radio Research Laboratories, designed particularly for studies of space communications, will be completed within the next few months. The station's principal antenna is a 30-meter-dia. paraboloidal reflector employing a Cassegrain feed. Operating frequencies will be: 1,725 mc, (transmit); 4,170 mc, (receive); and 4,080 mc and 136 mc, (tracking). Installation of a wideband transmitter, a communications receiver employing a liquid N_2-cooled parametric amplifier, and a tracking receiver will complete the facility, according to Nippon Electric Co., prime contractor for the station. The system already has been used for beacon tracking of *Relay, Telstar II* and *Tiros* satellites.

System Detects, Recognizes Geometric Shapes

Advances in the development of optical spatial filtering techniques may lead to early development of a practical automatic reading or translating machine. Under the joint sponsorship of the Army Electronics Command and the Air Force Avionics Laboratory, scientists at the University of Michigan Institute of Science and Technology have devised a complex filter capable of employing both phase and amplitude information without the use of auxiliary phase filters. Outputs are recorded directly on ordinary photographic film. No scanning is required. The experimental system includes a conventional coherent optical processing system, interferometers, and a gas-laser light source.

SPACE MEDICINE

Martin Apollo 'Flights' Require 28 Days

Four complete simulations of the *Apollo* lunar landing mission using a Lunar Excursion Module will be conducted this month at the Martin Co.'s Baltimore facility for the National Aeronautics and Space Administration. Twelve Air Force Aerospace Research Pilot School graduates will participate in the human-reliability studies in crews of three. Each simulation will take seven days and use a full-size Command Module and a simulated LEM crew compartment.

Infrasonic Dynamic Pressure Chamber Ordered

The latest simulation chamber to be built at the Aerospace Medical Research Laboratories at Wright-Patterson AFB will be a dynamic pressure chamber with a noise-generating capability equivalent to that produced by multi-million-pound-thrust rocket engines. This will mark the first human tests of infrasonic noise of this magnitude (1 to 30 cps). Air Force researchers will try to determine human safety limits and tolerances. MB Electronics, a division of Textron Electronics, Inc., will design and build the chamber.

ADVANCED MATERIALS

NOL Develops Sendust Sheet

A process for forming the brittle magnetic alloy of silicon, aluminum and iron—Sendust—into sheet form has been perfected by the Magnetism and Metallurgy Division of the Naval Ordnance Lab, White Oak, Md. The metal powder-rolling technique results in improved room temperature ductility. The lab reports an immediate interest in applications as recording and playback magnetic tape heads. The processed Sendust has a lifetime 100 times that of current materials. There are also applications in audio and pulse transformers because of the alloy's low losses at high frequencies.

Two-Phase Flow Choking Analyzed at NBS

Idealized design solutions for problems of choking two-phase fluid flow have been proposed by the National Bureau of Standards. R. V. Smith of the NBS cryogenic engineering lab studied hydrogen, oxygen, nitrogen and refrigerants and produced design recommendations in graphic form. Choking two-phase flow is defined as a Mach 1 condition of a liquid-gas mixture at the discharge of a constant area device or in a flow restriction in a system such that further reduction of downstream pressure will not increase the mass rate of flow. The data is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for $.75 under the title of NBS Technical Note 179 (Aug. 3, 1963).

Prototype Ti Component Lab Set

An engineering laboratory aimed at providing low-cost prototype titanium parts to speed development of new markets for the metal will be established in Monroe Township, N.J., by Titanium Metals Corp. of America. The lab will also conduct specialized investigations into the behavior of titanium under specific circumstances as requested by TMCA customers. The lab will concern itself only with limited size and low-quantity production parts, while TMCA will continue to recommend qualified fabricators for large production quantities of titanium parts. Missile and space applications took almost a third of the 12.3 million lbs. of titanium mill product shipments in 1963—by far the largest single customer area.

Silicone Shields F8U-2U from Sidewinder Exhaust

A spray-on coating of Dow Corning's 2-0103 protects the fuselages of the Navy's Crusader aircraft from the erosive exhaust gases of the *Sidewinder* missile it fires. The silicone rubber coating lasts through repeated launchings—up to 40—depending on conditions. More than 65 materials were evaluated by the Navy before the problem was solved.

PROPULSION

Polaris Ejection Rocket in Production

The small solid rocket developed by Hercules Powder Co. at its Allegany Ballistics Lab for the new *Polaris* missile ejection system is now in production at the firm's Kenvil, N.J., plant. The motor is mounted on the side of the *Polaris* launching tubes. *Polaris* launch power is provided by passing the hot exhaust gases of the motor through a water chamber, generating steam. The motor has a designed burning rate that provides an increasing volume of exhaust as the *Polaris* is forced up the launching tube. The system eliminates the complex valving and plumbing in the current compressed air ejection method.

Incentives Marked by Profit Formulas

Renegotiation Board not bound by DOD equations, but they are accepted as valid guidelines for justifying profits

by William Beller

COMPANIES EARNING profits on missile/space contracts with wide-ranging incentive fees may have to give back part of the money under a Renegotiation Board "no formula for profits" criterion.

It is very likely, however, that the documentation required by the Dept. of Defense to support the award of a large profit to a company will also help support that company's right to it in the eyes of the Board.

This is the feeling expressed in MISSILES AND ROCKETS' interviews held last week with Lawrence E. Hartwig, Renegotiation Board chairman, and Graeme C. Bannerman, Deputy Assistant Secretary of Defense (Procurement).

Asked if the Board went along with DOD's method of awarding profits on a formula basis—such as the one used on the Space Technology Laboratories contract for the nuclear detection satellite program, formerly *Vela Hotel*—Hartwig said "Congress instructed us to get away from formula renegotiation, and to apply judgment in each case. Where you have an act of such broad discretion as the Renegotiation Act, you cannot have certainty, as with a fixed formula."

Hartwig explained that with a formula rate of return, there would be no consistent rewards for companies operating efficiently or at low cost, no matter how ingeniously the rates were set. He pointed out, at the same time, that the Board does not examine single contracts, but looks over a company's entire contracts for the fiscal year.

"Ours is a fact-finding board looking for evidence of company efficiency and reasonableness of cost," said Hartwig. "Incentive is one of the keystones of the Act and is why the act is so broadly stated."

"Incentive" is also vital in DOD thinking. Bannerman said that DOD and the Renegotiation Board have been working very closely together for the past year, a fact confirmed by Hartwig.

- **Renegotiation up, profits down**—Since 1956, the total value of the contracts in the Renegotiation Board's backlog has steadily increased. At the same time, industry's profit rate, measured as a percentage of costs, has steadily decreased except for one two-year period when it remained constant. In 1956, for instance, the Renegotiation Board was processing $25 billion worth of contracts and the rate of profit was 6.1%; by 1962, the profit rate had dropped to 3.1%, and by 1963, the profit rate had dropped to 2.9% on a total of $31 billion worth of contracts.

These figures do not necessarily reflect the profit picture or the value of contracts open for renegotiation for any given year; the volume of the Board's work has put the agency between one and five years behind.

It is estimated that DOD spends between 75 and 80% of this money. The rest is spread between the Atomic Energy Commission, NASA, and to some extent the Federal Aviation Agency.

Practically all the business done by the Defense Dept. is subject to renegotiation. There are two main exceptions: 1) if a company does not have over $1 million in billing in the fiscal year; and 2) in the sale of standard commercial articles, which can be purchased on a price-competitive basis.

- **Board not a bogey man**—Bannerman said that companies probably are worrying too much about the possibility of the Renegotiation Board's taking some of the profits earned on an incentive contract. He stressed that the factors that yield a good profit for a company operating under an incentive contract are the same factors that the Board considers as a justification for earning such a profit; high risk-taking on the part of the company, good cost control, timely completion of the project and good performance of the hardware.

Bannerman pointed out that under incentive contracting, DOD actually assists the contractor with a well-documented record as to why he got his profit, which record can be presented to the Board. Incidentally, these data also help DOD get the performance records it needs in evaluating contractor performance.

"I see no conflict with what we are doing and with what the Renegotiation Board is set up to do; in fact, we complement one another," Bannerman told M/R.

He stressed, though, that such contracting by no stretch of the imagination means that the Renegotiation Board has abdicated in the field of incentive contracts.

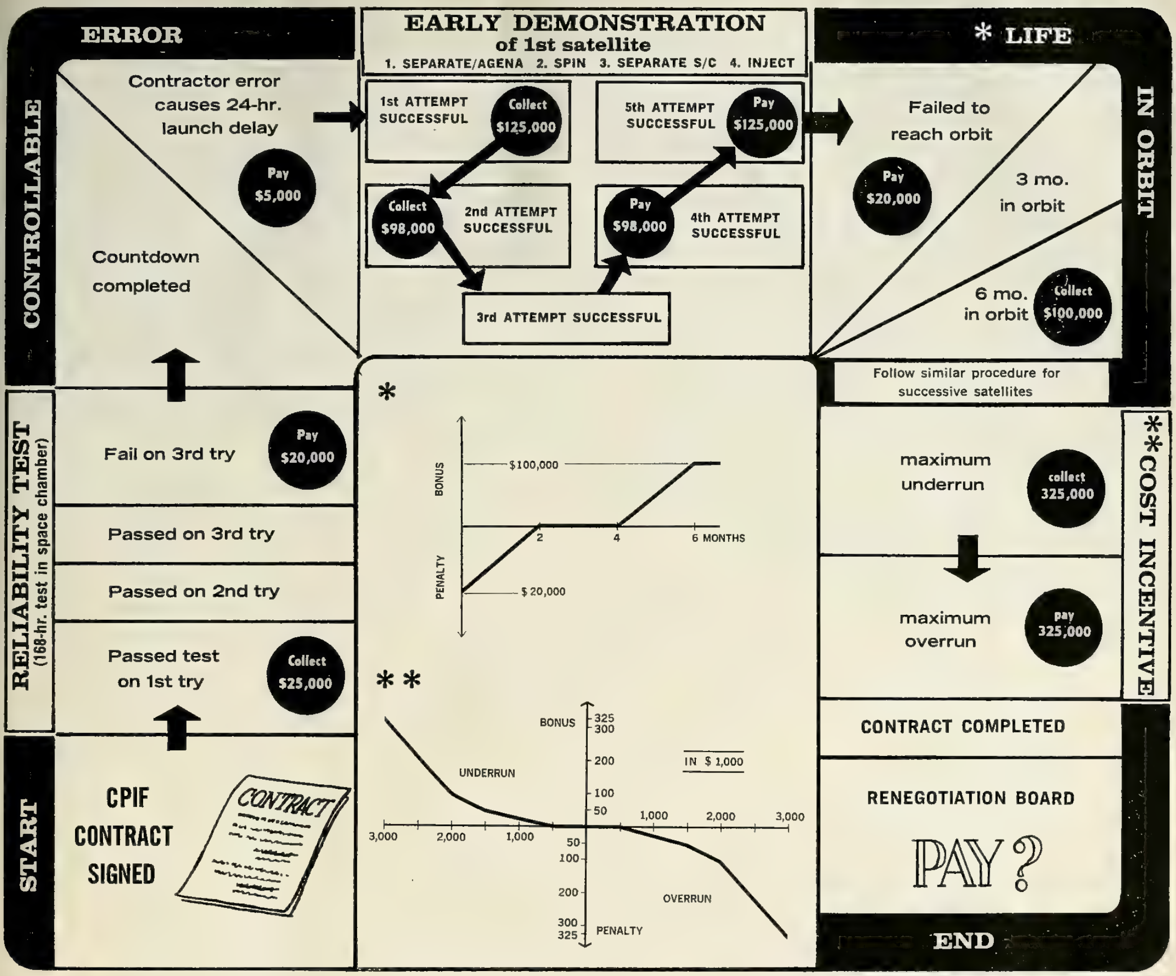
He added that inventiveness, innovation and initiative are to be encouraged on the part of the contractor, and will produce correspondingly high profits.

- **Incentive formula**—In incentive contracting, the cost-plus-incentive-fee works as follows: The total cost estimate may be $1,000. The total fee may be $70 or 7%. There will be an incentive swing from 0 to 14%. Thus, the contractor will find that if the cost rises to $1,500 as a maximum, for instance, he gets no fee, and if it is $500, say, he gets $140 profit.

On a fixed-price incentive, the government would share in good performance. It may be on an 80%-20% basis, wherein the government would get 80% of the cost savings and the contractor would get 20%—or any other relationship, depending upon the extent of risk the contractor takes.

- **Money-making machine**—As contractors gain experience with incentive contracting, they grow more enthusiastic about supporting this type of relationship with the government, according to Bannerman. This was borne out by a spokesman for Space Technology Laboratories—holder of the first DOD in-

INCENTIVE


ERROR
CONTROLLABLE
Contractor error causes 24-hr. launch delay
Pay $5,000
Countdown completed
EARLY DEMONSTRATION of 1st satellite
1. SEPARATE/AGENA 2. SPIN 3. SEPARATE S/C 4. INJECT
1st ATTEMPT SUCCESSFUL
Collect $125,000
2nd ATTEMPT SUCCESSFUL
Collect $98,000
3rd ATTEMPT SUCCESSFUL
4th ATTEMPT SUCCESSFUL
Pay $98,000
5th ATTEMPT SUCCESSFUL
Pay $125,000
* LIFE
IN ORBIT
Failed to reach orbit
Pay $20,000
3 mo. in orbit
6 mo. in orbit
Collect $100,000
Follow similar procedure for successive satellites
RELIABILITY TEST
(168-hr. test in space chamber)
Fail on 3rd try
Pay $20,000
Passed on 3rd try
Passed on 2nd try
Passed test on 1st try
Collect $25,000
START
CPIF CONTRACT SIGNED
CONTRACT
*
BONUS
PENALTY
$100,000
$ 20,000
2
4
6 MONTHS
* *
BONUS
PENALTY
325
300
200
100
50
UNDERRUN
OVERRUN
IN $ 1,000
3,000
2,000
1,000
**COST INCENTIVE
maximum underrun
collect 325,000
maximum overrun
pay 325,000
CONTRACT COMPLETED
RENEGOTIATION BOARD
PAY?
END

BRIEF IDEA OF THE GAME

INCENTIVE is a game for two players, the GOVERNMENT and a CONTRACTOR. The government starts out with all the MONEY. OBJECT of the game is for the contractor to take as much MONEY away from the government as possibie.

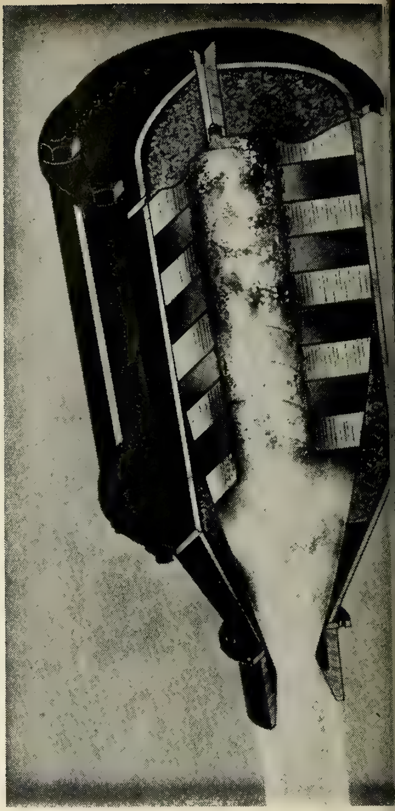
centive contract for a major space system—who enthusiastically told M/R that each of its two satellites in orbit will soon be earning a penny a mile, thereby transforming them into money-making machines.

This profit, of course, is the result of STL's successful organizing of 50 subcontractors and suppliers, working with eight participating Federal agencies. The program effected one million man-hours of research, development, design, fabricating, integrating and testing, and, this October, launched a pair of satellites that are operating so successfully that subsequent launches may not be needed.

The Advanced Research Projects Agency, contracting office for the nuclear detection satellites, possibly could save the Air Force several million dollars by shortening the program and at the same time get the same results called for by the original five-launch program. It is surmised that this reasoning lies behind the delay in orbiting the second pair of nuclear detection satellites.

- **Reflects government needs**—Incentive contracting forces government officials awarding such contracts to examine them very carefully to see if the government's needs are adequately given in terms of penalties and bonuses. If, for example, a development is to be completed between 32 and 36 months, but the exact time within this span is not too important, light penalties can be assigned as the period approaches 36 months. However, if failure to finish the contract by the end of 36 months might be costly to the government, heavy penalties could begin with every day following the 36th month. Bonus and penalty techniques for forcing companies to adhere to government objectives are presently being worked out.

Bannerman said inter-relationships of profits probably will be introduced by attaching multipliers of less than one to each of the profit factors. For example, if the three profit-making factors in an incentive contract are performance, time and cost, and if the contract is not being finished on time, then a contractor, besides losing some of his profit on the time factor, would also be assigned multipliers to performance and cost, thereby making it unprofitable for the contractor to ignore one factor in favor of another. ■



Honeycomb Propellant Matrix Could Permit Solid, Liquid 'Mating'

SRI experiments, under ARPA-funded Hexcel contract, spark industry studies, but firms lack enthusiasm

ARTIST'S CONCEPTION of a cutaway experimental honeycomb propellant matrix.

BERKELEY, CALIF.—Experimental firings at Stanford Research Institute have led to further work in industry to investigate feasibility of a honeycomb propellant matrix concept that would permit high-energy liquids, cured to a viscous state, to be packaged into "solid" motor grains.

Researchers believe the concept, originated by Wells A. Webb at Hexcel Products, Inc., may offer the possibility of designing strong propellant grains that have the advantages of both liquid and solid systems without certain disadvantages. Preliminary Hexcel investigations in 1959 led to $240,000 in funding from the Advanced Research Projects Agency.

The investigations have been aimed at showing that appropriate foil gage metal honeycomb can contain compatible or non-compatible propellants in solid or gel form in various cellular sizes and structural arrangements, and that combustible honeycomb can reinforce high-energy propellant grains with or without increased burning rates.

Non-compatible propellants are isolated in separate cells and the cells sealed to produce an end-burning grain. Mixing and combustion occur as the honeycomb burns away.

The honeycomb can also be arranged for burning in the across-cell direction where the flame front proceeds at right angles, burning through the cell walls.

SRI, which performed all propellant formulation and testing in the honeycomb propellant matrix (HPM) work under subcontract to Hexcel, conducted more than 80 experimental firings. Motors tested were 2-in. and 5-in. dia. and used aluminum honeycomb cells up to 0.25 in. across. Wall thicknesses ranged up to 5 mils. SRI's propulsion sciences division reported that firings yielded 87%-90% combustion efficiency.

Hexcel, not seeking to enter the rocket motor field itself, interested other firms and organizations in the research, including Lockheed Propulsion Co., Thiokol Chemical Co., United Technology Center, Hercules Powder Co., and Picatinney Arsenal. The concept has "shown some good-looking possibilities, but when they will be realized, or whether, remains to be seen," says one industry spokesman.

- **Early test results**—Initial investigations have shown that the honeycomb will not only contain viscous propellants without slump for long periods of time, but that it will permit smooth burning of the laminar-type grain that is formed by the array of honeycomb cells.

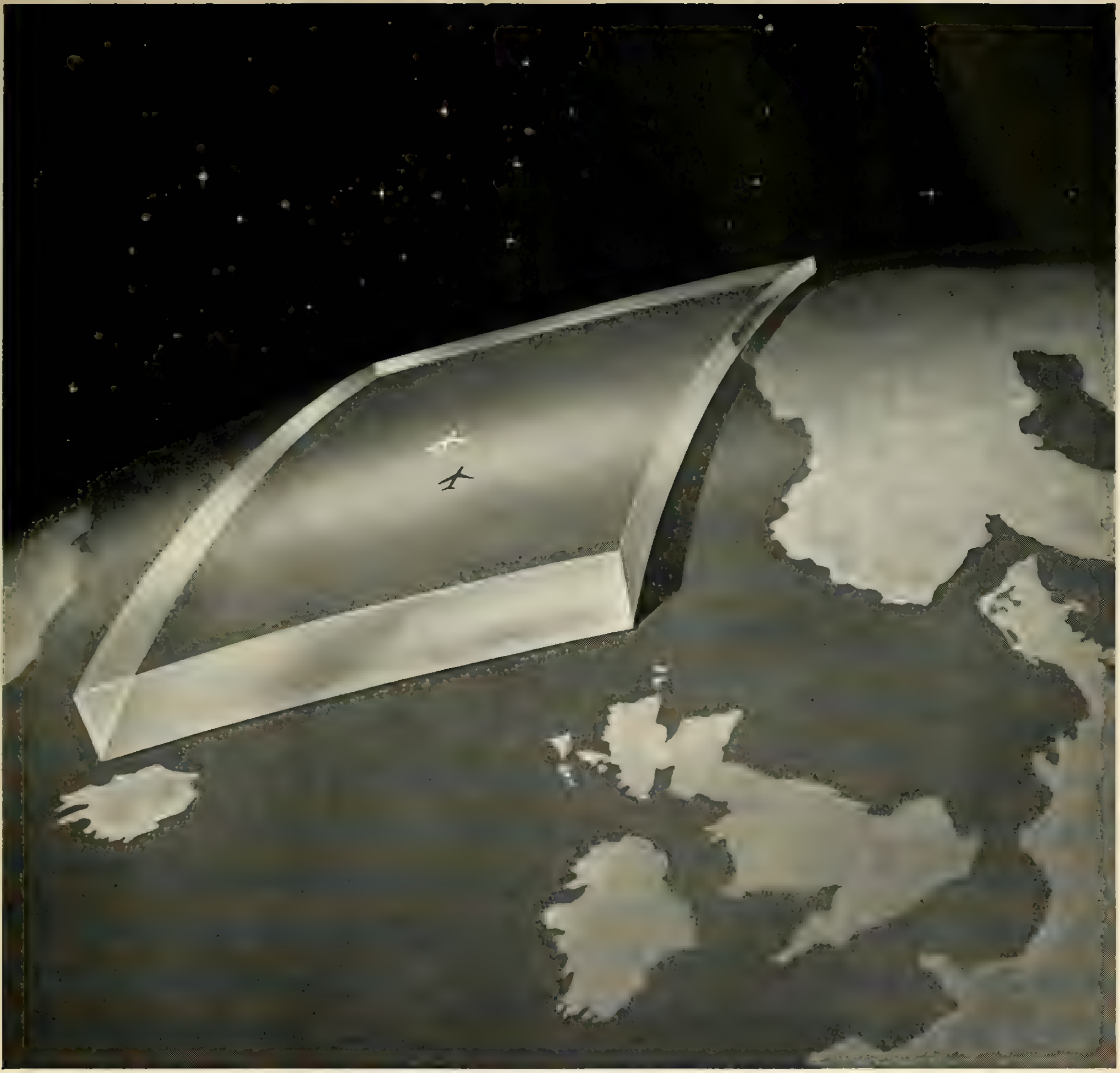
In the SRI work, thickened high-energy liquids were packaged in HPM structures that provided a unit with the configuration, case, and nozzle of a solid rocket. Various fuel-oxidizer configurations were tried with experimental success.

In initial experiments, a high-energy propellant selected for research purposes was cast in individual honeycomb cells and cured to a rubbery consistency. But it tended to shrink and pull away from the walls or distort the cells.

To alleviate this, SRI cured the same propellant only partially, to a fairly hard gelled but viscous state. In this state, changes in propellant volume were accommodated by fluid movement only in the cell axis direction, permitting the propellant to maintain contact with the cell wall and prevent the flame from entering the interior portions of the grain.

As heat was transmitted along cell walls, it was found, the propellant adjacent to the walls ignited sooner than propellant farther away, producing a pyramid-shaped surface within each cell, thus increasing the burning surface and burning rate.

Control of the increase in burning rate was achieved by selecting honeycomb materials of appropriate thickness



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Reflectone's signal generator system has been developed and proved in simulators for the B52B, F, G and H. For use in new aircraft configurations, this system would require development of only the student's mock-up station. Thus, through use of this advanced system, Reflectone can reduce development costs, insure reliability, and speed delivery—providing complex mission simulation well in advance of operational systems.

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In fifty years, what?

Perhaps the best way to look 50 years into the future of flight is to look back fifty years.

When the Wright Brothers achieved powered flight on Kill Devil Hill, did anyone expect to see supersonic aircraft? Aircraft carriers? Helicopters and hovercraft?

On July 20 of last year, United Technology Center fired a solid propellant rocket motor which developed over a million pounds of thrust—two and one half times the power needed to send astronaut Cooper into a 23-orbit flight last year. Where will this development lead in 50 years? Interplanetary freight lines? Space spas? Shipping fleets of rocket propelled craft?

One thing is certain: this country must continue to move out into space. Interplanetary exploration will soon provide the same opportunities that once took bold men across oceans and into new-found continents. In fact, space power may ultimately decide the fate of nations.

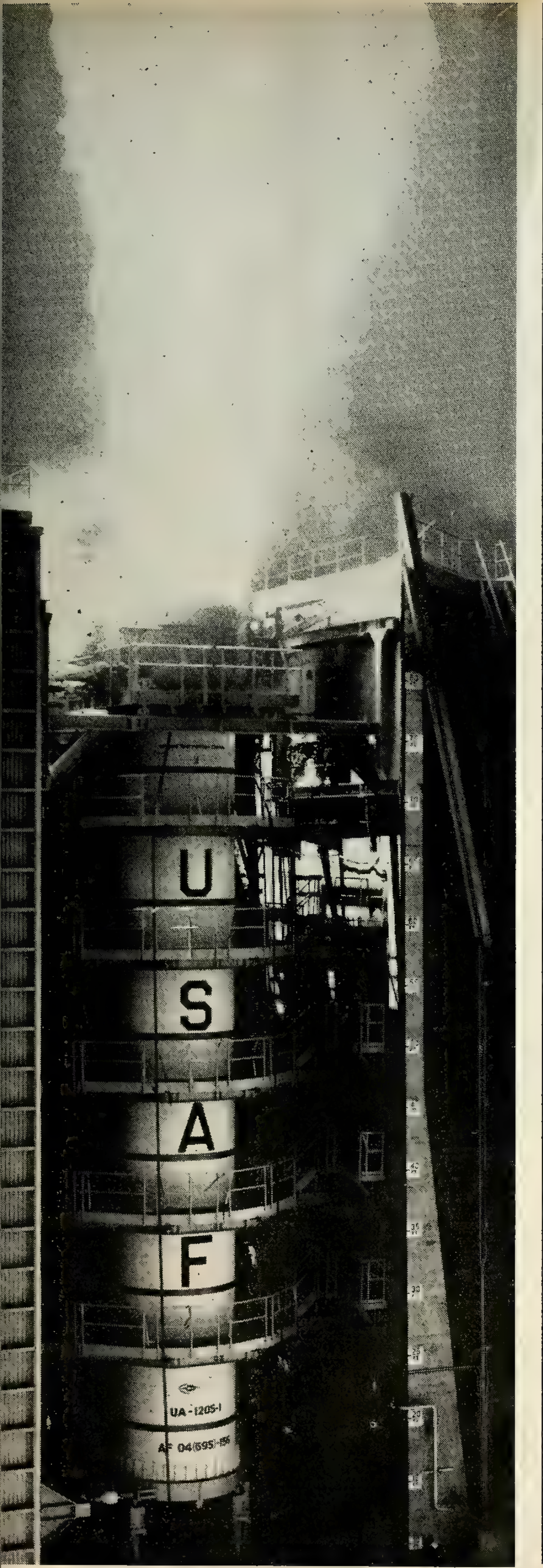
United Technology Center is among the leaders in research, development and production of the wide range of propulsion systems that will bring the space age to maturity. Concentrating its efforts on liquid, hybrid, and solid propellant rocket motors, UTC has demonstrated a capability ranging from giant first-stage "booster" motors to tiny retro-rockets and guidance motors for lunar landings.

UTC has contributed to a number of major developments in the field of space technology: the "building block" concept of segmented solid rockets; liquid rocket engine throttleability; the first fiberglass-filament-wound segmented solid propellant motor; hybrid engines that combine the advantages of both liquids and solids for start, stop, and re-start capability; thrust vector control of solid boosters; "space storable" fuels for liquid motors; and the successful firing of the first solid propellant rocket motor to develop more than a million pounds of thrust.

Two factors work together to make such accomplishments possible at UTC: the kind of people we have, and the tools we furnish them.

UTC is managed by a team of men who combine the roles of scientist and businessman. These men have a depth of experience and knowledge in rocket propulsion technology; their technical and administrative skills have already been demonstrated during exceptional careers both in defense programs and in private industry. Using the project management concept for complex programs in research and production, the individual project teams have at their disposal any technical capability within the company which is necessary to support a particular program.

To carry out these individual and combined efforts, UTC has made major investments in the future of space. A complex of company-owned facilities—designed expressly for the tasks at hand—has been established near Coyote, California, 25 miles southeast of the research, engineering and administrative headquarters at Sunnyvale. This huge Development Center is a completely integrated "factory" for developing, testing, and processing solid, liquid, and hybrid propellant engines. Facilities include the world's largest vertical test bay for solid propellant rocket motors, which can handle static firings with up to four million pounds of thrust;



production facilities capable of producing filament-wound motor casings up to 20 feet in diameter; in-ground ovens for casting and curing booster motors and motor segments over 200 inches in diameter; and a new generation of materials-handling equipment to process and move these mighty motors.

UTC's research and development programs are concerned with the broad evaluation of scientific phenomena as they relate to advanced propulsion concepts. These programs reflect UTC's interest in a broad spectrum of space propulsion activities: advanced high performance propellant ingredients, storable bipropellants, development of high-temperature metals and structural materials for engine systems, methods of ignition and thrust vector control, basic research in hybrid combustion, the response of materials and propellants to radiation and space environments, and many others.

As a natural corollary to these fundamental studies, UTC has accumulated "technical fallout" of great potential value to industries not directly related to space: high strength metals, chemical processing techniques, specialized electronics systems for data gathering, advanced techniques in plastic fabrication, plus a surprising number of new uses for materials that have long been familiar to science and industry.

United Technology Center's present position in the rocket propulsion field is not a matter of chance. As an operating division of United Aircraft Corporation, it draws on a depth of technical, financial and management resources accrued by the parent company during four decades of flight propulsion accomplishment.

Accelerated by the spur of national interests, the rapid development of space technology in the United States is inevitable. Through careful planning and dedicated effort, UTC will continue to play an important role in that development.

United Technology Center
SUNNYVALE, CALIFORNIA

UTC

DIVISION OF UNITED AIRCRAFT CORPORATION

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TAPE COPY STATION FOR ATLANTIC MISSILE RANGE

Six 1.5-mc Mincom CM-100 Recorder/Reproducers form the backbone of an extremely complex tape copy station delivered to the Atlantic Missile Range. This station makes possible for the first time as many as five first-generation copies of prime data tapes in one operation. In addition to the six CM-100's, it also includes two 600-kc Mincom G-100's, two degaussers, and an advanced monitor alarm system policing forty-two 1.5-mc channels. The station is the result of Mincom's long experience with frequency responses of better than 1 mc — an outstanding reliability record since 1955.

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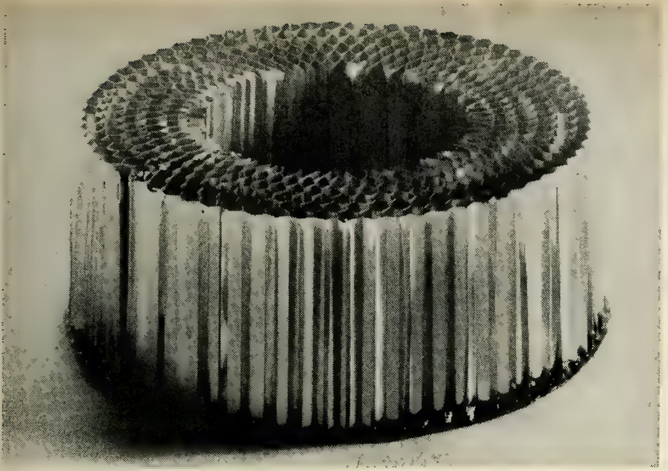

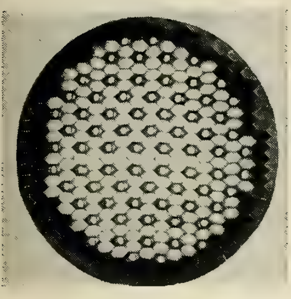

ABOVE: Section through closure of a composite end-burning honeycomb-structured grain with ports to selected cells. LEFT: Edge-stabilized section of fanwise expanded annular honeycomb. RIGHT: Eighty experimental firings with 2-in. and 5-in.-dia. motor grains have proved potential feasibility of honeycomb propellant matrix.

and materials, metal or plastic. The matrix may comprise only 3% of the system weight. It does not add significant combustion heat to the system.

The concept's originators believe it could offer a means to produce high-energy grains of great structural strength for high-acceleration vehicles, although appropriate centrifuge research remains to be done.

- **Lockheed sees potential**—Industry researchers so far do not seem overly excited about the concept, believing it presents complications that may outweigh advantages. Lockheed Propulsion Co., however, which now employs Webb, the originator, as a senior technical specialist in its propellant application department, reports that its own small-scale firings indicate the concept may offer possibilities in three areas:

—Separation of very-high-energy, partially cured, liquids to achieve a "solid" grain.

—Use of materials, both solid and liquid, of good performance but having poor structural properties.

—Control of burning rates over a wide range.

Problems involved in the approach include:

—Filling the cells and later cell leakage.

—Bonding of the honeycomb matrix to the motor case. In some designs and with some materials, there are problems of flashdown burning between the propellant and honeycomb material. Bonding within the honeycomb material itself also presents problems.

—The honeycomb system can be highly anisotropic in its burning characteristics, behaving much the same as wires in propellant.

- **Enthusiasm is restrained**—LPC, which has only a modest exploratory effort underway, reports it is less interested in the structural properties of HPM than in other possible advantages.

UTC reports HPM shows some promise in a number of high-performance systems. The firm is looking at the concept "in more than just liquid applications." However, effort to date has not been on a large scale because researchers feel the approach may be too complicated.

SRI used a composite, double-base propellant in a number of firings. In firings designed to test the separation qualities of the honeycomb matrix, a fuel, cast as an irreversible gel, was inserted into some cells. Oxidizer-rich propellant was inserted into other cells. Isolation of the two ingredients was successful.

SRI conducted extensive experimentation with the adjustment of both the propellant viscosity and the cell configuration. The experiments indicated that changes of honeycomb configuration were possible to allow for use of either conventional fully-cured solid propellants or propellants in a semi-liquid state. The concept appears applicable where propellants may be incompatible with curing agents.

- **Configurations tested**—The honeycomb was tested in a variety of configurations. Smooth burning resulted from firing of end-burning grains and two tubular grains. The honeycomb in both grains was adapted in the shape of a doughnut sandwiched between outer layers of self-supporting oxidizer.

In one doughnut shape, the honeycomb cells were parallel to the grain cylinder axis. In the other approach, the cells were oriented radially, perpendicular to the grain axis.

The parallel-axis configuration produced fairly smooth burning. Burned out inhibitor casings taken from motors after firings showed nearly complete utilization of the honeycomb. The remaining material amounted to less than 0.5% of the initial propellant weight.

SRI tried aluminum coated with polyethylene, uncoated aluminum and stainless steel as honeycomb material, later using aluminum exclusively. ■

Data-Processing System Aids Zeus Development

by Michael Getler

U.S. ANTIMISSILE system designers are being aided by a new digital data-processing system now in full operation at the Army's *Nike-Zeus/Nike-X* test complex at Kwajalein Island in the Pacific.

Designated the Model II *Zeus* Defense Center Tape and Buffer System (ZDCTBS), the new installation is a subsystem of the *Zeus* Acquisition Radar Data-Processing net. It helps to analyze the performance of the *Nike-Zeus* Track Processor and its associated Target Detector and Coordinate Converter from the tape records of their outputs.

In effect, introduction of the TBS to the Acquisition Radar (AR) extends operational analysis and simulation capabilities from an earlier single-target processing system used with the *Zeus* Target Track Radars (TTR's) into multiple-target environments associated with the AR.

In the *Zeus* Defense Center concept, the AR complex serves to initiate all subsequent action. Targets detected at relatively long ranges by the AR are passed on to discrimination radars for decoy/warhead sorting and then on to the TTR's, which track single targets for individual missile intercepters. Whereas the earlier TBS systems dealt with the single-target TTR problem (M/R, Oct. 30, 1961, p. 29), use of an advanced TBS unit with the AR—where the number of targets at least theoretically approaching several dozen in number might have to be handled, almost simultaneously—represents a much more complex recording problem.

The ZDCTBS, located in the same building as the AR transmitter and receivers, takes data on-line via cable connections, rather than on tape as in earlier systems, from the AR special-purpose computer, or Track Processor. Data are recorded and then translated by the TBS from the high-density *Zeus* format into the standard IBM word format for subsequent analysis or simulation use through a general-purpose IBM 704-type computer.

• **Functions**—The Model II TBS is primarily a recording and analysis mechanism for improving the techniques of missile defense and scoring the effectiveness of actual intercepts being made against *Atlas*- and *Titan*-boosted test vehicles in the continuing round of Pacific test firings. The system also serves an important secondary function as a simulation device capable of translating a standard computer-format intercept program into a format which looks as though it were generated by an operational AR system. Along these same lines, engineers report the system has been very useful in setting up the A-ICBM systems operation.

In addition to the primary analysis and simulation modes of operation, there are several other operator-selected modes associated with on-line systems test, checkout and display.

Since the ZDCTBS system must be capable of taking a great deal of data very rapidly—faster than it can be put on magnetic tape for recording, the system is designed with two coincident current memories or buffers. Automatic switching circuits channel data into the second buffer after the first has been fully loaded, allowing the contents of the first buffer to be recorded while the second is loading incoming information.

Included in the TBS inputs are such parameters as target X, Y, and Z coordinates, a time base, and assigned individual target track numbers.

Several special-purpose computers, designed by Bell Telephone Laboratories, in the overall AR system are associated with the Track Processor, Coordinate Converter (to polar coordinates) and Target Detector. The TBS provides links between all of these special computers in addition to the link with the General-Purpose IBM 704 computer used in the simulation and analysis role.

The Model II ZDCTBS was designed and built for the Army-Bell Labs-Western Electric Co. *Zeus* team by Radiation, Inc. The Melbourne, Fla.-based firm has been building TBS units for the *Zeus* program since 1959, including equipments for the TTR, an earlier version of the ZDCTBS, since modified to Model II status, for the White Sands test center, and most recently, a system which now is operating with the *Zeus* Discrimination Radar at Kwajalein. Total contractual value of the firm's efforts in this area is estimated at about $5 million.

• **Future uncertain**—The ZDCTBS Kwajalein set-up has now reportedly been in full operation for about six months. Test firings of *Zeus* from White Sands have been completed, and the program will be continued at Kwajalein as part of the *Nike-X* development effort (M/R, Dec. 23, p. 9).

Though the TBS unit at Kwajalein is now said to be probably the major current means of collecting and evaluating A-ICBM performance against multiple-target threats, and though informed sources say it is aiding development plans for *Nike-X* system design, the future use of these units in any forthcoming *Nike-X/Sprint* development site is not at all certain. Despite on-line display and checkout capabilities, use in operational sites would be quite limited, project engineers say.

The ZDCTBS uses two Ampex TM-2 digital tape handlers for recording data from the track processor and playing it back for conversion to IBM format. The TM-2's are also used in selecting data to be typed out for display by a Friden Flexowriter. The system also has an Ampex FR-400 tape handler used for recoding data for analysis in IBM 704 format. These tapes, or tapes generated by the 704, according to Radiation, may be played back on the FR-400 for entry into the track processor or the flexowriter.

Search and type features of the TBS, Radiation points out, provide typed copy of the data stored on either the TM-2 or FR-400 tapes. The Flexowriter also produces a punched tape for making copies of original data.

The Model II system is also reported to have an expanded test and checkout capability, including the ability to check out virtually the entire system with the exception of certain computer interfaces without the associated computers in operation. The TBS also contains the logic necessary to test the computer modes of system operation.

Performance of the system during operation can be checked from the control center by parity error indicators and data and control indicators. Individual circuits can be monitored at test points in the test panel. ■

Lockheed's new Research Center:

An advanced aerospace complex for the Southeast

Today, more than 3,000 Lockheed-Georgia employees are scientists and engineers. And the number is constantly increasing. To provide more modern facilities for their important work, the company is building a multimillion-dollar Research Center near the main plant in Marietta. The first door will open this year. The entire facility will be completed in 1965.

This new Lockheed-Georgia Center marks a major milestone in the Southeast's continuing advance into the space-nuclear-electronics age. Among the research and development activities to be carried out in the modern complex will be space studies, aerospace sciences, physics, chemistry, metallurgy, nucleonics, mathematics, hypersonic navigation, communications, and human factors.

The Research Center complements Lockheed-Georgia's nuclear facilities at Dawsonville, Georgia, as well as additional research, development, and engineering operations throughout the entire Lockheed-Georgia plant.

Lockheed-Georgia Company, Marietta, Georgia: a division of Lockheed Aircraft Corporation

Lockheed-Georgia

Titan III-C 'Stage Zero' Role Revamps UTC Structure

Firm has had to acquire skills not usually associated with propulsian contractors; 40% of work subcontracted

by Robert Lindsey

SUNNYVALE, CALIF.—Motor design is absorbing barely 40% of United Technology Center's development effort on the solid-propellant first stage for *Titan III-C*, emphasizing a significant aspect of the program that could portend further shifts in the traditional division-of-labor structure within the aerospace industry.

In a little noticed facet of the project, the Air Force *Titan III*-624A program is the first in which a propulsion company has developed an entire stage for a major rocket system. The United Aircraft Corp. division is responsible not only for developing the 120-in. solid motors for *Titan III-C's* "stage zero," but also handles every aspect of the stage except guidance—from ground-support equipment to flight controls.

As the first year of the development program ended last month, company officials told MISSILES AND ROCKETS the new approach has made substantial changes in the makeup of the company, requiring acquisition of skills, resources and other capabilities not traditionally within the sphere of propulsion contractors.

- **Concept's advantages**—Despite a few problems, they said, the new approach is proving itself by eliminating or reducing interface problems among contractors, speeding up communications between engineering groups working on related subsystems, expediting a

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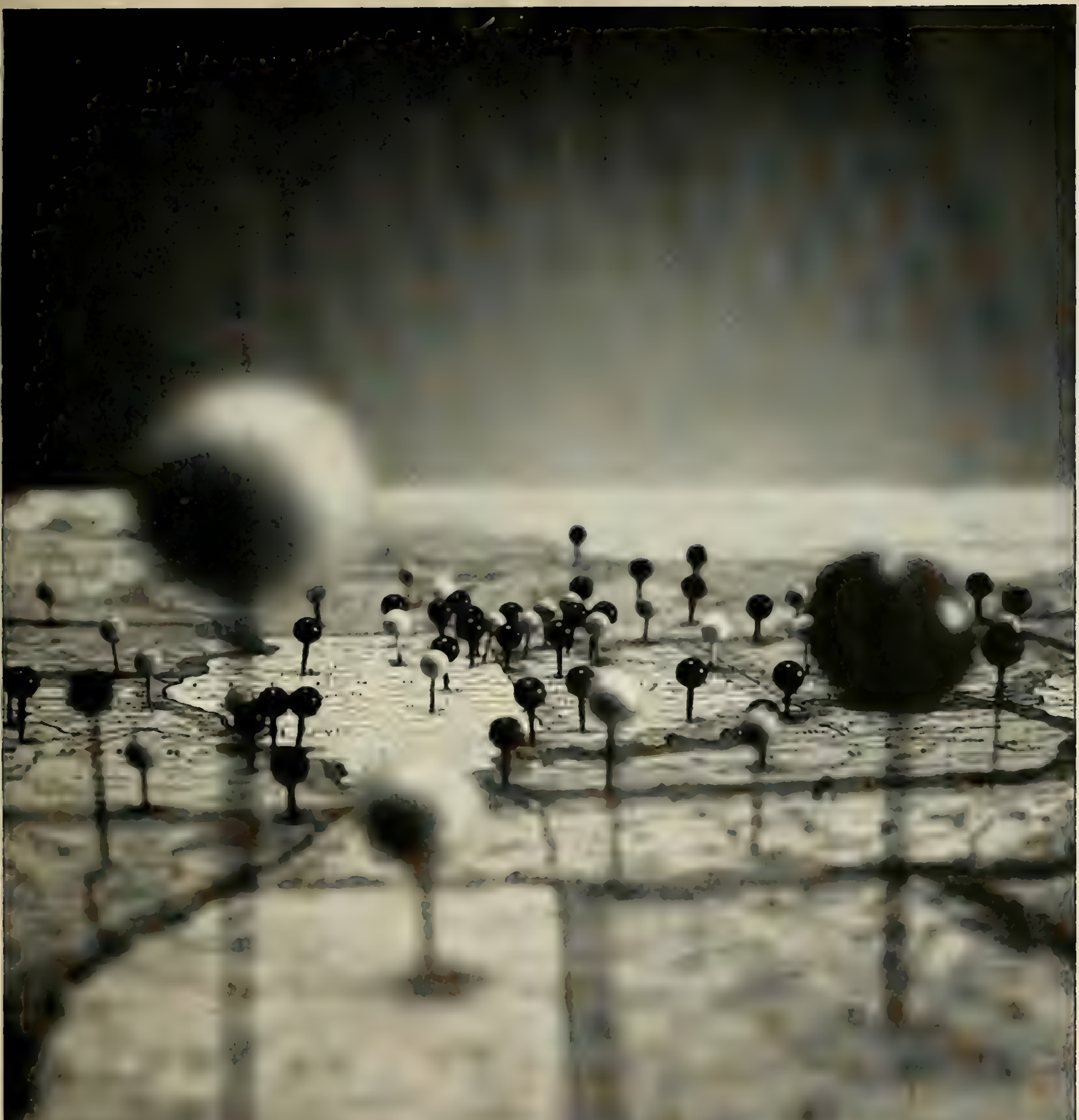

Task Force. Under Sperry systems management, 337 companies, including 18 major subcontractors, share responsibility for the navigation of every Polaris-firing submarine. It was Navy's precept that the nation's best talents be teamed for the job.☐ Because the system must continuously and precisely provide exact position information for launching the Polaris, our long experience in navigation and inertial technology made Sperry a logical management choice.☐ Among new technologies contributed to the program by Sperry were ultra-low drift gyroscopics, the SINS inertial system, the advanced NAVDAC computer, and new processing techniques for a sea of technical and management data. Vital to U.S. defenses, Polaris will serve other free world forces as well. *SPERRY POLARIS, Sperry Gyroscope Co., Great Neck, New York.*

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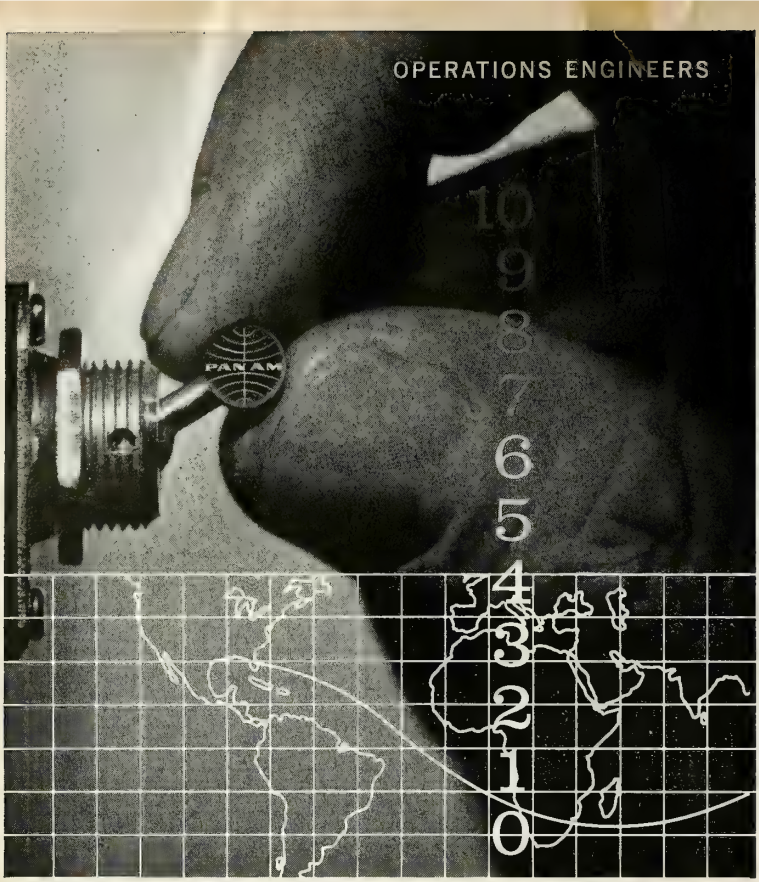

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THE
FIRING
LINE

of the Big Birds at the Atlantic Missile Range

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totally integrated design approach, and giving management a more confident hand.

Some evidence of the soundness of the approach will be demonstrated Jan. 25 when the second full size, five-segment *Titan III* solid motor will be tested at UTC's Coyote test facility near here.

Essentially, the test motor will be identical to that fired successfully last July 20. The initial motor, however, included several components made before the final design was firm. The upcoming test will be of a full prototype.

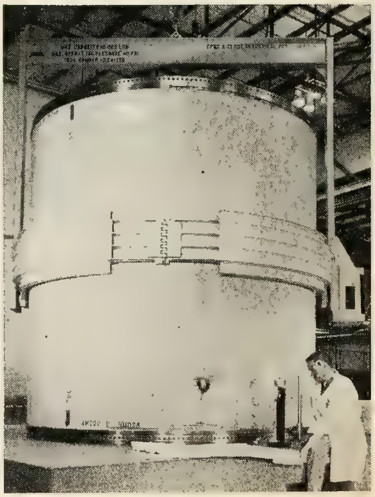
Chief improvements include slight changes in the grain configuration; the secondary fluid injection thrust-vector-control system will be complete; and minor changes in the distribution of insulation will be made.

In previous major missile and rocket programs, propulsion contractors have supplied only the basic engine. This concept was perhaps an extension of the division-of-labor approach of the aircraft industry, where engines and airframe are produced by different manufacturers. UTC is developing both.

- **Adjustments required**—Dr. Dean Rains, manager of the fluid and control systems branch in the 624A program for UTC, said the stage-manager approach poses many new challenges for a solid propellant rocket maker, requiring capabilities new to the propulsion industry, including these:

—Vehicle integration, including interface with other stages.

—Launch operations, including final



SECOND UTC-developed 120-in. motor segment like this one will be fired Jan. 25. Firm's first test of such a segment last July 20 was highly successful, but the segment included several components made before the final design was firm. Upcoming test will be of a full prototype.

assembly, check-out and count-down.

—Structures.

—Thrust-vector-control systems.

—Vehicle electrical systems.

—Flight instrumentation.

—Ground-support equipment, including mechanical and electrical systems for transport and assembly and automatic checkout equipment.

—"Software," including training, human factors analysis, logistics and maintainability.

One statistic clearly indicates the impact of the approach: Of some 500 UTC engineers on the program, less than 200 are dealing with the motor; the rest are working in the so-called "new" areas.

Rains said UTC has employed a nucleus of engineers assembled when the company was born to direct its entry into non-motor areas. Most of the specialists who contributed to UTC's proposal in the 120-in. competition now direct groups assigned to engineering of these areas.

He added, however, that UTC is relying heavily on the engineering forces of program subcontractors. Much of UTC's engineering role is monitoring subcontractors; a surveillance approach is eased by the program's heavy state-of-the-art emphasis and extensive "pre-engineering" during the program-definition phase of the program, plus heavy emphasis on quality control and reliability testing by UTC.

In some cases, components are a design collaboration of UTC and the subcontractor. Others are designed by the subs, while still others are UTC designed and made by subcontractors to its specifications (See box).

- **Big slice subcontracted**—UTC says it is subcontracting approximately 40% of its funding in the 624A program. This means subs will share roughly $70 million for the motor-development phase, which runs through the third quarter of 1966.

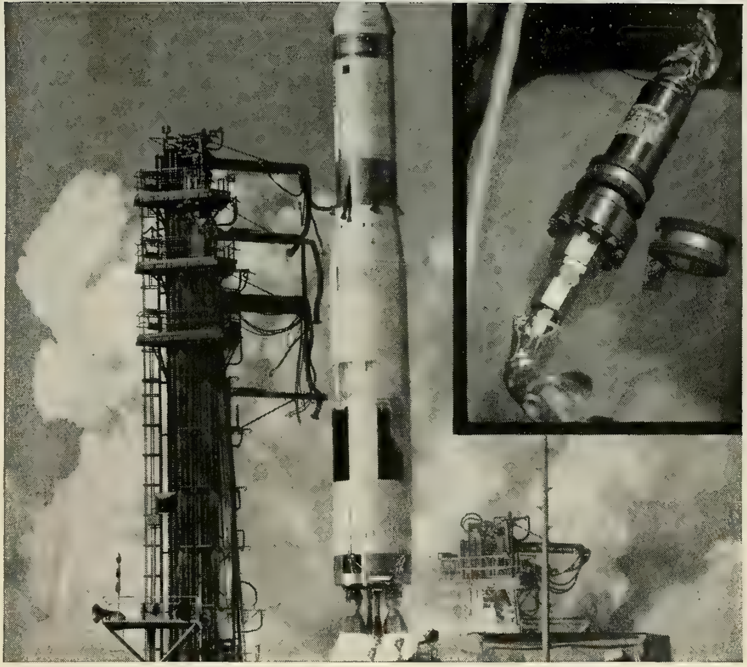
Asked to describe problems generated by the company's assignment as a stage-management contractor, Rains said integration of all aspects of the effort into direct management lines was initially a problem but this has long since been solved.

"The area in which we had to learn the most was vehicle integration . . . how to operate with interfaces. We had very few experiences we could draw upon. In vehicle checkout and launch base operations we've also had to start from scratch."

Also, he said, the company didn't realize initially the extensive commitment that would be necessary in such fields as human factors, training, logistics and maintainability.

- **Interface obstacles cut**—Reduc-

Taber TELE·NEWS
about TELEDYNE® and TELEFLIGHT® pressure systems



Taber Transducers are Martin choice to pick up engine data during Titan flights

Operating as components of a Martin Co. Instrumentation System, Taber TELEFLIGHT® Bonded Strain Gage Pressure Transducers gather important engine performance data during flights of the Air Force's Titan I ICBM. The 0-750 psia Taber Transducer, shown above, checks the pressure of engine number one thrust chamber. Three other Taber Transducers are used to measure (1) engine number one start gas pressure, (2) sustainer engine LOX injector manifold pressure, and (3) sustainer engine gas generator pressure. Martin chose these instruments "because of their ability to continually give accurate data even when subjected to extreme temperatures."

Taber performance advantages are many: long term stability, infinite resolution, hysteresis less than 0.25% full scale, and low sensitivity to temperature effects, shock or vibration. Models are produced for a wide variety of test, ground support or airborne applications, with pressure ranges from 0-5 to 0-20,000 psi. Write for literature.

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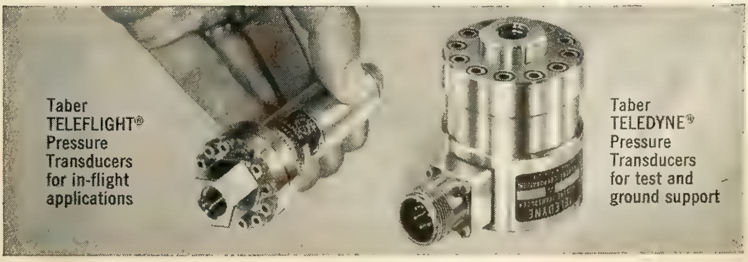
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SPACE AND INFORMATION SYSTEMS DIVISION
NORTH AMERICAN AVIATION

ing interface problems among contractors has proved to be one of the most significant technical and time-saving advantages of a system in which the motor manufacturer develops the rest of the stage, he said.

Integration of motor and structure, for example, is greatly eased because the same stress-analysis group works with both the motor-design group and the structure-design group, eliminating perhaps several layers of interface problems.

The dual 120-in. motors, initially regarded as the first stage of the *Titan-III-C,* are now known officially as "stage zero," to avoid confusion with the stage designations of *Titan II.*

Reviewing last July's 120-in. maiden firing, UTC spokesmen said it successfully confirmed the system's basic design, specifically its grain, nozzle, case, ignition and thrust-vector-control systems.

The firing yielded data for several improvements in the TVC system. Relatively few changes in the motor were dictated by analysis of data from this test, company officials said. Changes in distribution of insulation within the motor is regarded as the most prominent change resulting from data analysis.

● **Education in welding**—UTC engineers reported welding technology has been the biggest problem in the program. "This has been the eye opener," one engineering administrator said. "We've learned you have to develop new welding techniques when you enter these new areas with large size hardware."

Poor welds, too little strength and ductility plus other flaws have caused rejection of components submitted by subcontractors. But welding technology improvement is managing to slowly meet the demands, they said.

UTC has two advantages going for it in transition from a propulsion R&D company to manager of a major rocket stage development effort. It was a relatively new company when it won the 624A contract, so it entered the new fields directly, without the evolutionary problems of a more established rocket developer.

Secondly, a large solid-motor stage, as advocates of solids have long argued, is essentially much simpler than a large liquid-fueled system. The motor is a much smaller factor in the total complexity of the system than in a liquid propellant stage. Therefore, a proportionately larger factor of a company's capabilities can be devoted to non-motor areas.

Although some industry sources doubt the approach will ever become widespread, it has set a precedent and it is testing the propulsion industry's flexibility. ■

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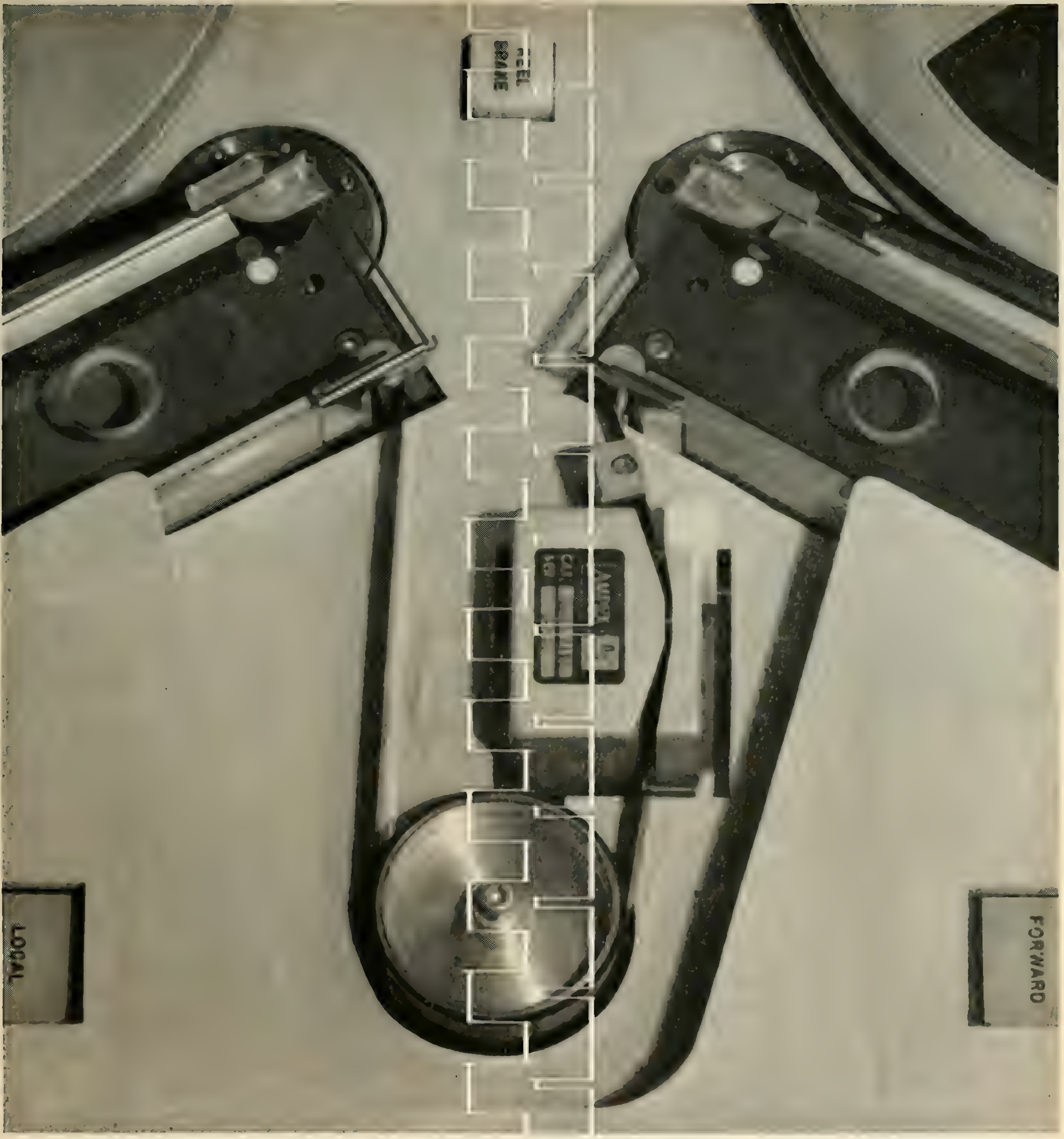

What has a drive concept so simple it's revolutionary? AMPEX TM-7

Here's a transport that's far in advance of anything in its class—the all new Ampex TM-7. It's a low-cost tape transport designed for less maintenance, less tape wear. And its most advanced feature is the revolutionary single capstan drive system. The new drive system has three major moving parts—a capstan and two reels. As a result, most of the components found in this type transport have been eliminated. Maintenance is far less. And tape wear? Virtually none. The two vacuum chambers keep a uniform tape tension on the capstan. There is nothing to smear the tape; nothing to stretch it. Tapes last and last. Even the old soft-binder tapes can be used with very little wear. The new Ampex TM-7 is completely compatible with IBM tape formats and with other Ampex equipment. It has a packing density of 200 and 556 bpi. A tape speed of 36 ips. A start and stop time of 10 ms with tape distance held within ±10%. Also, Ampex designed a new series of data and control electronics for the TM-7 to provide low-cost tape memory systems. The TM-7211 is a complete memory system enclosed in a 19 inch rack cabinet. And the TM-7212 is a complete shared system with four TM-7 transports in one cabinet. Write to the only company providing recorders, tape and core memory devices for every application: Ampex Corporation, Redwood City, California. Worldwide sales and service.

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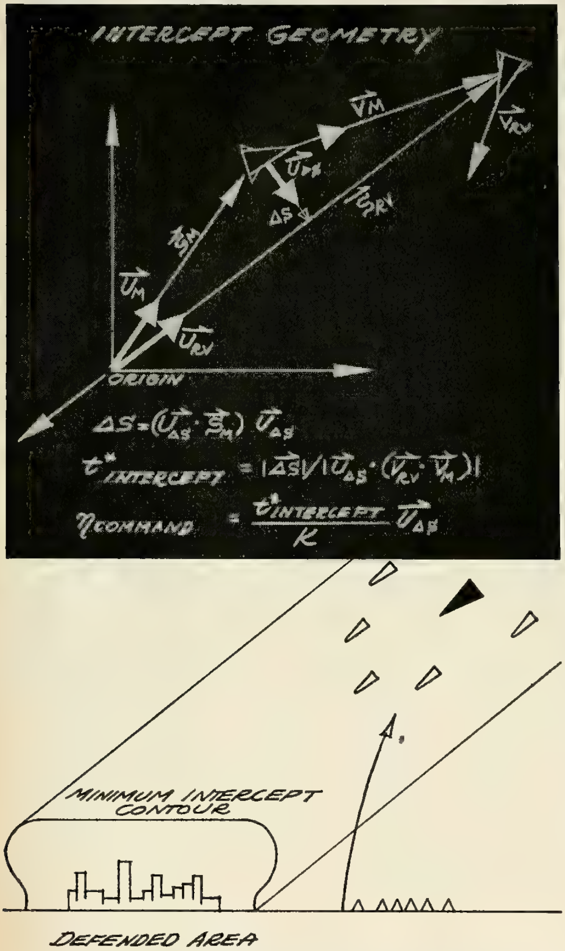
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MINIMUM INTERCEPT CONTOUR
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WITH ASSOCIATES LIKE THESE...

Mr. E. P. Williams (left) is Chief of the Aeromechanics Branch, Advance Missile Technology. He directs efforts in the Flight Mechanics, Aerothermodynamics, Aerodynamics and Nuclear Effects Sections. Mr. Williams was among the Douglas engineers who went with the Rand Corporation when it became independent of Douglas in 1948. He became head of Aerodynamics at Rand and specialized in hypersonic aerodynamics and glide rocket research and engineering.

Mr. J. L. de Grandpre (right) is Douglas Study Director for the USAF Foreign Technology Division, Analysis and Synthesis of Military Space Systems. Previously he was Director of the Advanced Computer Program Development Section within Advance Missile Technology. Earlier, he was engaged in systems analysis and flight simulation work in Canada.

...IN THIS PROFESSIONAL ATMOSPHERE

The Douglas Advance Missile Technology Department is a professional community charged with the responsibility of evolving new concepts which contribute to the technical superiority of the nation.

It combines research and advance design functions in a self-administered unit having the atmosphere of a small, highly qualified engineering organization. But it also has the advantage of having at hand the vast support functions and facilities of a major aerospace company. Its studies are tempered by the scientific critique of its research groups and the realism required by the knowledge that eventually "hardware" end products are involved.

AN INVITATION. Key openings are now available for qualified professionals with experience and/or advanced degrees, particularly in the disciplines of aerodynamics, communications, guidance and control, flight mechanics, fuzing and arming, and operations analysis. We invite you to look into them by writing (please include resume) to the following address:

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Mergers and Acquisitions

Garrett Corp., Los Angeles, will merge with Signal Oil and Gas Co. Jan. 20. The merger was arranged last fall as a means of strengthening Garrett's position in resisting take-over by Curtiss-Wright Corp. (M/R, Oct. 28). . . . *Radiation Service Co., a subsidiary of Radiation Incorporated, Melbourne, Fla., has acquired Alert Communications Co., Villa Park, Ill.* . . . Ling-Temco-Vought, Inc., Dallas, has agreed to sell its Ed Friedrich, Inc., subsidiary to American Investors Corp. of Phoenix, Ariz. The sale was said to be in keeping with LTV's policy of "divesting itself of interests not basically related to the electronics and aerospace industries." Friedrich makes air conditioning and refrigerated display equipment.

New Firms and Divisions

Radio Corp. of America has established a new microwave solid-state engineering activity at the headquarters of RCA Electronic Components and Devices in Harrison, N.J. The move is in connection with recent consolidation of RCA's Electron Tube and Semiconductor divisions. . . . *Consolidated Dynamics Corp. has been formed as a 50/50 joint venture on the parts of SCM Corp. and Taller & Cooper, Inc., a subsidiary of Apollo Industries, Inc. The new firm will make specialized data-collection equipment at an SCM plant in Orangeburg, S.C.*

Industry Facilities

United Technology Center has begun construction on a $400,000 rocket motor packaging and shipping building at the firm's Coyote (Calif.) processing and test center. The 13,000-sq.-ft. building will be used for inspection, preparation and packaging of the 50-ton segments and other large components of the solid-propellant rockets that UTC is building for the Air Force's Titan III-C standard launch vehicle. . . . *Hazeltine Corp. is transferring its technical development operations from Indianapolis, Ind., to the company's Greenlawn, N.Y., site where the firm recently completed a 50,000-sq.-ft. development laboratory.* . . . Admiral Corp. is to move its Palo Alto, Calif., production and research operations to company headquarters in Chicago. The move will consolidate all of Admiral's military production and engineering facilities in Chicago. . . . *Sylvania Electric Products, Inc., has opened a field office at Grand Forks AFB, N.D., to direct installation of the underground communications system for the Minuteman system there. Some 950 miles of underground cables will link 165 missile sites with control centers over 7,500 sq. mi.* . . . Hollywood Plastics, Inc., Los Angeles, manufacturer of thermoplastic shipping and storage boxes for missile/space products, has leased a 30,000-sq.-ft. building to expand raw materials storage and protective storage for dies. . . . *International Telephone and Telegraph Corp. has opened a new research facility in San Fernando, Calif. . . . The 53,000-sq.-ft. facility will be engaged in studies in optical communications and electronic surveillance R&D. The move brings ITT's gross plant investments in California to $42 million.* . . . Thiokol Chemical Corp.'s Panelyte Industrial Div. has dedicated a new research laboratory in Trenton, N.J. The 8,000-sq.-ft. lab will include a research section for in-glass experimentation, a pilot plant that will include complete processing equipment such as a self-contained high-pressure press and a pilot-sized treater, and an instrumental analysis section. Over half of the building is to be used for pure research, while the remainder will consist of research offices and other support areas. . . . *Edgerton, Germeshausen & Grier, Inc., electronics and nuclear science firm has opened a 30,000-sq.-ft. laboratory in Santa Barbara, Calif. The new facility cost some $750,000 and permits consolidation of EG&G's Santa Barbara operations. One structure houses a linear accelerator for use in high-energy nuclear physics research.*

Company Representatives

Dana Laboratories, Inc., Santa Ana, Calif., manufacturer of electronic equipment, has named Applied Science Associates to represent its product line in Texas, Oklahoma, Arkansas and western Lousiana. ASA has headquarters in Dallas and a branch office in Houston. . . . *Magnetic Core Corp., Newburgh, N.Y.-based specialist in the manufacture of powered iron components for electrical and electronics applications, has appointed five new sales representatives to cover 13 states and Canada. Reed & Riddett Co., Littleton, Mass. is to serve all of New England; Robert Neill Co., Toronto, Onterio, will cover Canada; Connolly & Co., Mountain View, Calif., will be responsible for northern California, Oregon, Washington, Nevada, Utah and Colorado; southern California will be the territory of the Mulvin Co., Inc., of Pasadena; and Stasco, Irving, Tex., will service Texas.*

Miscellaneous Intelligence

The Outer Baldonian "legation" in Washington has placed advertisements in the *Wall Street Journal* and other newspapers expressing a desire to commission the building of a rocket "capable of carrying 15 pounds of mail 16 miles and releasing it upon radio command." The "principality" of Outer Baldonia is located off the coast of Nova Scotia, and is owned, governed, constituted—and sometimes solitarily inhabited—by former Pepsi Cola executive Russell M. Arundel, who apparently has a postal delivery problem. The legation is prepared to consider proposals from interested rocket manufacturers. Address: Legation of Outer Baldonia, 203 World Center Building, Washington 6, D.C.

AWARDS

AIR FORCE

$12,000,000—**Boeing Co.**, Seattle, for further work on *Minuteman* ICBM's.

$7,200,000—**Sylvania Electric Products, Inc.**, Waltham, Mass., for further work on electronic systems related to *Minuteman* ICBM.

$5,000,000—**Olin Mathieson Chemical Corp.**, Saltville, Va., for production of anhydrous hydrazine for *Titan II* program.

$3,300,000—**Sylvania Electric Products, Inc.**, Mountain View, Calif., for continued work on *Minuteman* ICBM's.

$2,100,000—**Lockheed Missiles and Space Co.**, Sunnyvale, Calif., for PMR launch service applicable to *Agena D* boosters for calendar 1964.

$1,400,000—**North American Aviation, Inc., Rocketdyne Div.**, Canoga Park, Calif., for *Atlas* missile propulsion systems.

$1,000,000—**University of New Mexico**, for follow-on work for research and operation of the AF shock tube facility at Sandia AFB, N.M.

$747,000—**Lear Siegler, Inc.**, Santa Monica, Calif., for production of test equipment and spare parts for AN/TPQ-11 cloud-height radar.

$338,722—**Dow Chemical Co.**, Midland, Mich., for high-energy solid-propellant fuel.

$275,000—**Shell Development Co.**, Emeryville, Calif., for synthesis of high-energy solid-oxidizer binder propellants.

$240,000—**Texaco, Inc.**, New York City, for basic chemical research for advanced storable liquid oxidizers.

$83,451—**Cornell Aeronautical Laboratories, Inc.**, Buffalo, N.Y., for research study of high-temperature phenomena in hypersonic flows.

$51,000—**University of Akron, Institute of Rubber Research**, Akron, Ohio, for study of low-temperature propellant polymerization.

Fairchild Camera and Instrument Corp., Fairchild Space and Defense Systems Div., Palo Alto, Calif., for experimental design of single-axis flight-control system utilizing microelectronic techniques (undisclosed amount).

ARMY

$5,300,000—**Dynaelectron Corp.**, New York City, for missile test data collection.

$1,100,000—**Technical Operations, Inc.**, Burlington, Mass., for research and studies to support Combat Development Command Program.

$500,000—**General Dynamics Corp., Pomona Div.**, Calif., for Fiscal Year 1964 *Redeye* missile research and development program.

$79,055—**Vitro Corp. of America, Vitro Labs Div.**, West Orange, N.J., for impacting plasma studies including acceleration investigation.

NAVY

$4,800,000—**Westinghouse Electric Corp.**, Sunnyvale, Calif., for technical engineering assistance on *Polaris* missile launching systems.

$1,232,000—**Maxson Electronics Corp.**, Great River, N.Y., for production of center or "warhead" sections for *Bullpup* air-to-surface missiles.

NASA

$1,800,000—**General Dynamics Corp., Astronautics Div.**, San Diego, Calif., for space boosters for *Orbiting Astronomical Observatory (OAO)* program.

$1,499,111—**Martin Co.**, Baltimore, for one-year study of large launch vehicle.

$334,409—**Sperry Rand Corp., Farragut Div.**, Bristol, Tenn., for vehicle simulation system.

$177,533—**Thiokol Chemical Corp.**, Bristol, Pa., for feasibility test program of integral mandrels for large solid-propellant boosters. Work to be performed at Huntsville, Ala.

$85,293—**Dynamic Science Corp.**, South Pasadena, Calif., for study to determine requirements for facility to investigate electrical hazards to spacecraft.

$83,200—**Defense Research Corp.**, Santa Barbara, Calif., for study of amplification of acoustic disturbances by oscillatory chemical reactions.

$55,234—**B.F. Goodrich Co.**, Akron, Ohio, for design, fabrication and testing of microwave absorbent materials for installation in anechoic chamber facility at Goddard Space Flight Center.

$53,656—**Republic Aviation Corp.**, Farmingdale, N.Y., for mapping study of radiation-safe corridor.

$40,477—**Northrop Corp., Nortronics Div.**, Palos Verdes, Calif., for spare parts to maintain stable platform subsystem.

U.S. COAST GUARD

ITT Federal Laboratories, Nutley, N.J., for development of components for worldwide network of Loran-C long-range navigation ground stations (undisclosed amount).

AEC

Martin Co., Baltimore, for development of advanced nuclear electric generator for undersea navigation beacons and deep-sea oceanographic research (undisclosed amount).

INDUSTRY

$4,000,000—**Kaiser Aerospace & Electronics Corp.**, Oakland, Calif., from **Thiokol Chemical Corp.**, for production of thrust-vector-control nozzles for stage I engines for *Minuteman* ICBM's.

$768,000—**Systems Programming Corp.**, Santa Ana, Calif., from **Jet Propulsion Laboratory**, for programming support to JPL computing center and technical staff in study and solution of problems associated with planetary and lunar space missions conducted by JPL for NASA.

$247,000—**D.B. Milliken Co.**, Arcadia, Calif., from **The Boeing Co.**, for *Dyna-Soar* photo-instrumentation systems.

$200,000—**RdF Corp.**, Hudson, N.H,. from **North American Aviation's Space and Information Systems Div.**, for design, development and manufacture of specialized high-accuracy temperature transducers.

$164,346—**Cook Electric Co., Wirecom Div.**, Chicago, from **Bendix Corp's Radio Div.**, for d-c coil relays to be used at high degrees of no-contact-miss ratings in dry-circuit systems.

$45,000—**Mellon Institute**, Pittsburgh, from **Lockheed Propulsion Co.**, for metallurgical studies of 156-in.-dia. solid-propellant feasibility demonstration program being conducted by Lockheed.

$33,000—**Documentation, Inc.**, Bethesda, Md., from **Council on Library Resources, Inc.**, for further development of portable, inexpensive reader-printer for microcopies which possess capability of producing paper prints of selected microimages.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

U.S. Army Natick Laboratories
Natick, Mass.

Negotiations will be conducted with Goodyear Aerospace Corp., Litchfield Park, Phoenix, Ariz., for modification and fabrication of pilot's torso lifeshields leading to fabrication of five each pilot's torso shields. RFQ AMC(X)-19-129-64-327-JQ. Note: For information only. RFQ not available.

Directorate of R&D Procurement
Systems Engineering Group (RTD)
Wright-Patterson AFB, Ohio

Negotiations will be conducted with Technology, Inc., Dayton, Ohio, for advanced electromagnetic compatibility techniques investigation. This is a continuation of Contract AF 33(657)-11119. Note: For information only. RFP not available. RFP N1-5418-KEB.

Research in new techniques of thermocatalytic combustion encompassing (1) high-temperature refractories radiating preferentially in the infrared; (2) sub-surface ignition techniques; (3) techniques leading to elimination of flashback problems; (4) techniques leading to reduction of visible radiations; (5) techniques leading to same element of spectral control within near-IR region of spectrum; and (7) use of exotic fuels for energy source. Briefing will be scheduled in the RFP. Request for this RFP must be in writing. Address your requests to Seg (RDT) Attn: SEKEB. Wright-Patterson AFB, Ohio. RFP N-5392-KEB.

Headquarters
Ballistic Systems Division
Attn: BSQKE
Norton AFB, Calif.

Research and development and production of WS-133B security subsystem, 410 launch facility systems, plus indefinite number of spares. Various destinations. RFP 04694-64-194Q. RFP due date 2-12-64. Only two sources have been requested to submit proposals. These two sources have been selected based on earlier work accomplished by both contractors on the WS-133A security subsystem. Adequate plans, drawings or specs to describe requirements are not available. The firms to submit request for proposal are: Boeing Co., P.O. Box 3707, Seattle 24, Wash., and Sylvania Electric Products, Inc., Electronic Systems Div., Mountain View, Calif. It is suggested that small business firms and others interested in subcontracting opportunities make direct contact with the above firms.

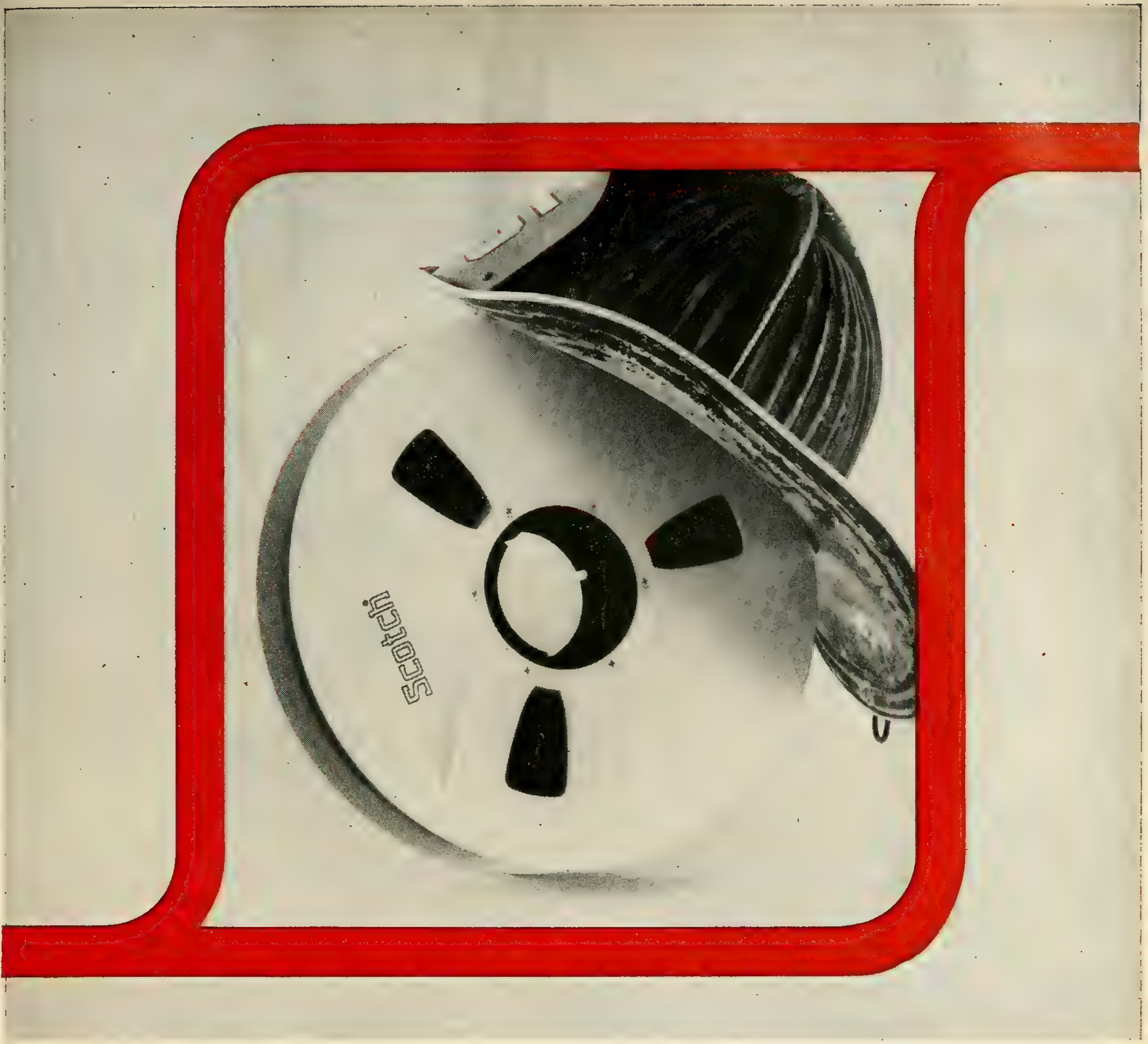
Aerospace Medical Division
Attn: AMKRB
P.O. Box 35448
Brooks AFB, Tex.

Negotiations will be conducted with Northrop Space Laboratories, Hawthorne, Calif., for research and reports on data survey and analysis of animal and human exposure to high wind blast. For information only. RFP not available.

Negotiations will be conducted with Regents of the University of California for research and research reports on subconvulsive effects of UDHM on nervous system. For information only. RFP not available.

Directorate of Procurement
Arnold Engineering Development Center
Arnold AFB, Tenn.

Negotiations will be conducted with Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y., for further research and experimental studies of surface catalysis in non-equilibrium flows. Note: For information only. RFQ not available.



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SCOTCH® BRAND Heavy Duty Instrumentation Tape is the name. And it takes hot recorder heads in stride by resisting tape surface temperature as high as 250°F! Shrugs off the intense, localized heat that higher tape speeds and tensions build up at recording heads. Keeps the magnetic record straight by minimizing rub-off, protecting against drop-outs.

What's more, "SCOTCH" Heavy Duty Tapes, with a special high-potency oxide and binder formulation, outwear ordinary tapes *at least* 15 times. Conductivity is greater, too. 1000 times! Drains off static before it can attract dust, cause trouble. Exclusive built-in Silicone lubrication minimizes head and tape wear. 16 different heavy-duty constructions meet all requirements, even involving extremely high speeds, short wavelengths.

Scotch
magnetic tape
3M

TECHNICAL TALK Bulletin No. 3 discusses effects of frictional heat on tape performance as well as heavy-duty oxide and binder formulations. Free. Write 3M Magnetic Products Division, Dept. MBW-14, St. Paul 19, Minn.

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Magnetic Products Division 3M COMPANY

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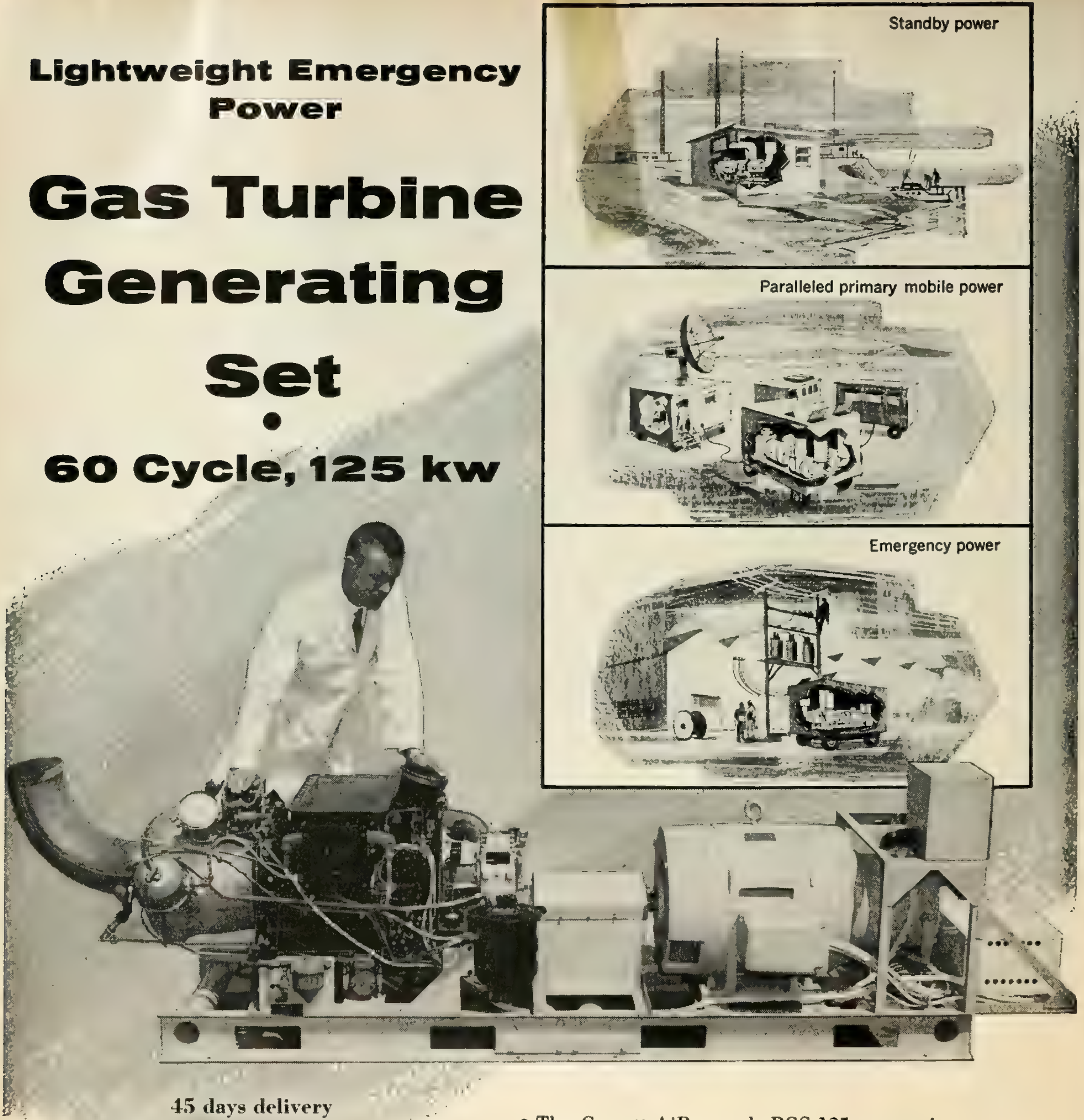
60 Cycle, 125 kw



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Accepts full load in 20 seconds
Two or more sets may be operated in parallel
Over 100 pounds-per-minute bleed air available

- The Garrett-AiResearch PGS-125 generating set requires no special installation. It is readily moved, and may be quickly separated into two parts for helicopter lift. Enclosure is optional. It is backed by AiResearch experience in building over 10,000 gas turbine engines. Parts and service are already available on a world-wide basis. For information on the PGS-125, or other available systems ranging from 30 to 300 kw, contact AiResearch, Los Angeles.

GARRETT

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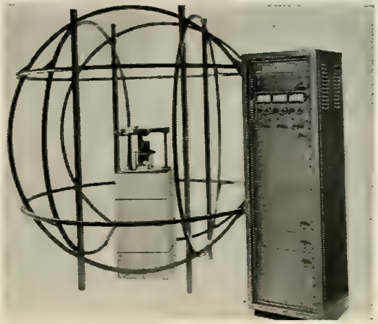
Circle No. 19 on Subscriber Service Card

New Product of the Week: Magnetic Environment

Vickers, Inc., Div. of Sperry Rand Corp. has developed a dynamic controlled magnetic environment, called the DYCOME$_{tm}$.

The unit provides a constant, precise and uniform field of any desired magnitude within a ±600 milligauss range, and will maintain a zero magnetic field in any location. It automatically nulls ambient magnetic disturbances, thus eliminating the need for shielded rooms and remote installation locations. The system consists of a three-axis Helmholtz coil available in 4-ft. or 8-ft. dia., a three-axis fluxgate magnetometer probe assembly, and a control console.



Specifications include an accuracy of ±2.0 milligauss, response down 3 db at 10 cps and power requirements of 60 to 400 cps.

Circle No. 151 on Subscriber Service Card

Output Amplifier

A single-ended output amplifier designed for amplification of low-level emf signals has been introduced by Electronic Associates, Inc.

The Type 6.544 thermocouple unit features gain to 10,000, and consists of a converter, ac amplifier, rectifier and high-gain dc amplifier. Input impedance is 10 megohms minimum; output impendance is 0.1 ohms typical with a gain accuracy of ±0.1%. Output voltage range is ±10v minimum; open loop dc gain is 3 x 10^7 minimum; drift is 0.1 μv/°F.

Circle No. 152 on Subscriber Service Card

Recorder Calibrator

MED Electronics, Inc., has available a light, portable, multiple range, reference source for calibrating dc chart recorders.

Check measurements may be obtained through a vernier output control knob, which gives potentiometer control over any one of 3 millivolt ranges. Power is furnished by two standard type "D" flashlight batteries and one mercury cell. The unit weighs 12½ lbs.

Circle No. 153 on Subscriber Service Card

Loop Recorder/Reproducer

A continuous loop recorder/reproducer designed for data reduction or data monitoring and storage where machine workload is heavy has been by Consolidated Electrodynamics Corp.

The GL-2810 handles magnetic-tape loops at any of six tape speeds from 60 ips through 1⅞ ips. The tape transport accommodates ½ or one-in.-wide tape loops. Separate plug-in record and reproduce amplifiers of direct FM or PDM types provide optimum system makeup and change flexibility.

Circle No. 154 on Subscriber Service Card

High-Temp Transducer

Winsco Instruments & Controls Co. is marketing a series of resistance temperature transducers, designed for application in advanced rocket engines.

The series operates at temperatures up to 1,700°F and vibration levels to 100 g's. It is available in several mechanical configurations and two basic electrical terminations, one being a high-temperature connector rated for continuous operation at 1,500°F and the other, a swaged tubing rated for continuous operation at 1,700°F.

Circle No. 155 on Subscriber Service Card

Inert-Atmosphere Canner

An inert-atmosphere canner, designed for protective packaging of delicate parts and sensitive instruments, is being marketed by FMC Corp.'s Central Engineering Laboratories.

The system consists of three functional units: a vacuum/pressure chamber; a vacuum pump and a variable speed drive. The canner evacuates the can and seals the part or instrument in an inert gas. The type of packaging excludes all oxygen. The unit meets MIL-P-116 specifications and provides a storage life of up to 5 years.

Degree of vacuum (up to 29.9 in. of mercury), length of evacuation cycle, duration of purging cycle, purging pressure, gases used for purging, number of purging cycles, pressurization for sealing, gases used for sealing and speed of rotation during sealing are all variables the operator can control.

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Thin-Film Bonder

Unitek Corp. is marketing Modular Microbond, a thin-film bonder developed for single surface welding of wire of 0.001 in. in diameter and ribbon of 0.001 in. thick and 0.02 in. wide to deposited thin-film circuits of 300 Angstroms or more.

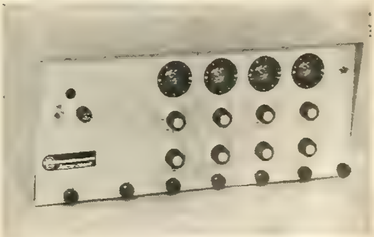
The system has an input of 100 to 130v ac, 50 to 60 cps. Weld power is provided by three sequential cycles, each independently controllable for weld pulse duration and amplitude. Cycle duration is controllable from 0 to 1,000 milliseconds, cycle amplitude from 0 to 100 watts into a 0.10-ohm load.

Circle No. 157 on Subscriber Service Card

Electronic Counter-Controller

U.S. Electrical Motors is marketing a line of electronic counter-controllers with count totals up to 999,999 and count rates of 300,000 per minute.

Designated the Accra-Count, the line includes digital totalizers, digital batch controllers, digital rate and speed indicators, and digital ratio indicators and controllers.



The units provide for a direct readout in the form of cold cathode counter tubes, with a standard option of NIXIE in line numeric readout. An end-of-count pulse generation can be provided without loss of count.

Customer requirements are matched by the use of standard enclosed modules which are used as "building blocks."

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missiles and rockets

DOD Military System

A Report on the DDR&E

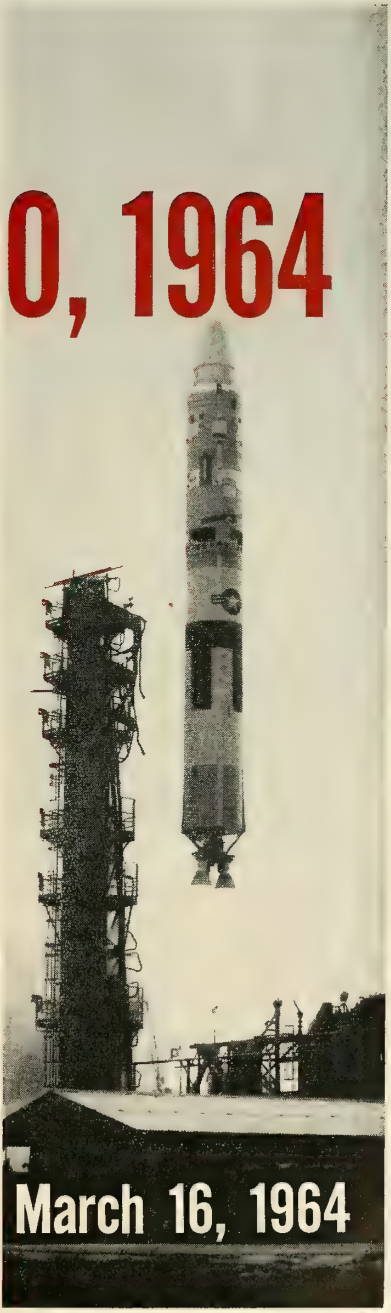
DDR&E, the Directorate of Defense Research and Engineering, is one of the most important offices in the Department of Defense. It has a complement of 145 men, supervising some 30,000 others and directly affecting over 125,000 industry personnel. DDR&E annually contracts for $7 billion dollars in space and military systems research, development, test and engineering services from its suppliers.

The March 30 issue of MISSILES AND ROCKETS will present an in-depth report on DDR&E covering:

DDR&E Operation ▪ Relationships with Industry and the Services ▪ Current & Advanced Programs ▪ In-House R&D Capabilities ▪ Future Expenditures ▪ Key Personnel

Issue Date: March 30, 1964

ssue, March 30, 1964



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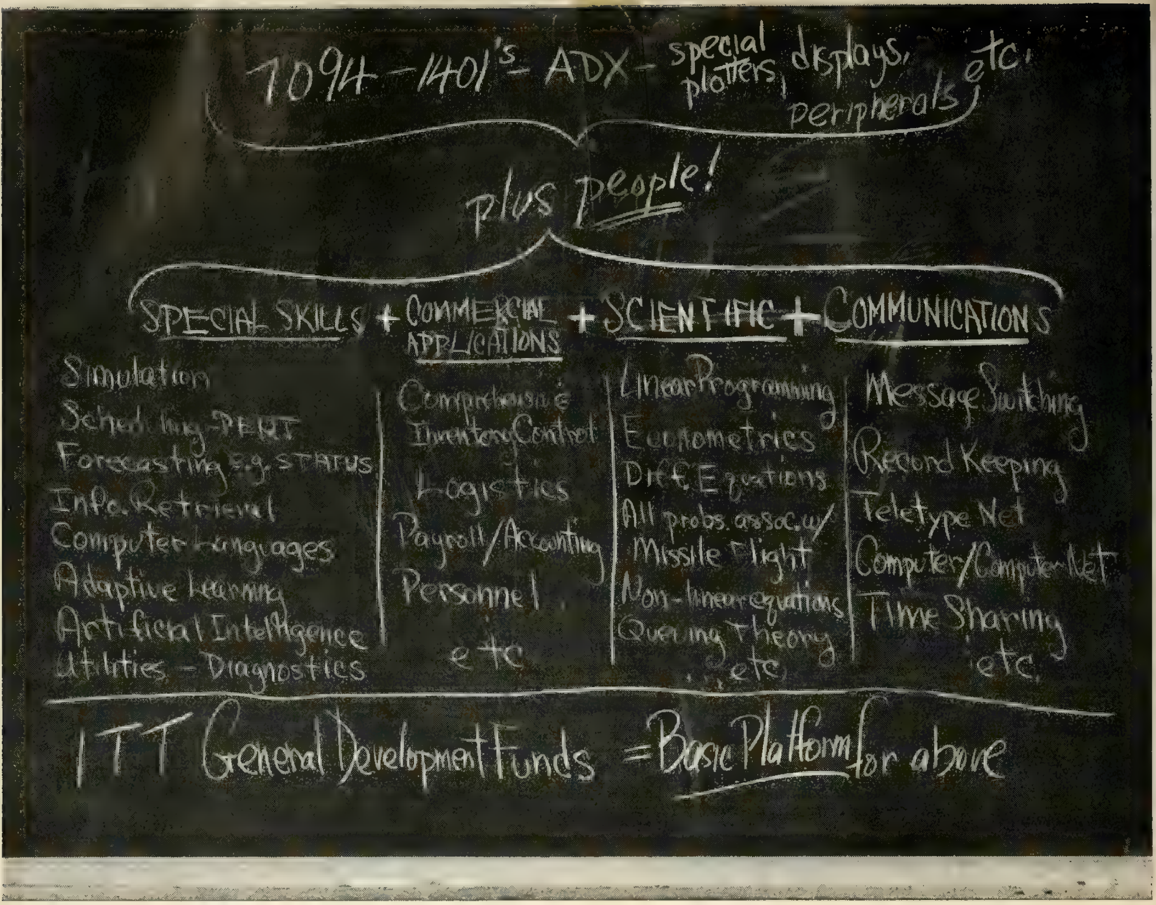
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ITT DATA AND INFORMATION SYSTEMS DIVISION

Tunable X-Band Filter

A wide-band Yttrium iron garnet filter for microwave applications operating over a 8.0 to 12.4-gc tuning range is available from Physical Electronics Laboratories.

The device has a frequency drift from −30° to 70°C, less than 50 kc/°C, and a tuning sensitivity of 10 mc/ma. Bandwidth at the 3-db points is 30 mc ±2 mc and at 30 db, is 225 mc. Insertion loss at the center is less than 2.5 db.

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Flash Machine

Edgerton, Germeshausen & Grier, Inc., is marketing a variable energy and pulse duration flash machine for applications in laser pumping.

The unit is capable of generating peak-power electromagnetic radiation pulses at lengths of 2.7, 1.25 and 0.66 millisec. duration. Energy per flash is variable from 2,000 to 13,000 joules.

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High Field Generators

Advanced Kinetics, Inc., is offering a series of high field generators in both air-cooled and liquid-cooled models.

Energy storage of 6,000, 12,000 or 18,000 joules is available. The 6,000-joule unit has a rise time of less than 5 μsec. and generates peak current pulses up to 200,000 amps. The 12,000-joule unit generates up to 400,000 amps; the 18,000-joule unit, up to 600,000 amps.

The units have a 10-kv power supply and triggering circuitry with external synchronization mode.

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DC-AC Inverter

Instrumentation and Control Div. of PneumoDynamics Corp. is marketing the Model 653A square wave inverter, designed for high reliability under extreme environmental conditions.

Th 28-v solid-state inverter has an input source of 115v ac, 400 cps, for gyros, torquers and other electrical instruments. The unit incorporates a two-transformer inverter circuit for maximum efficiency and minimum line current ripple. Efficiency is better than 72% at 80 va; temperature range is −55° to 70°C; output power rating is 80 va.

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Dry-Film Lubricant

A non-flammable dry-film lubricant, containing dispersed colloidal molybdenum disulfide for high load service, is available from Acheson Colloids Co.

Designated 'dag' 211, the lubricant is applicable for oven, furnace and kiln mechanisms, asbestos and metallic gaskets and seals, wire-drawing lubricants and stop-off coatings. The ultra-fine size of the molybdenum disulfide resists settling of the particles in the container and promotes long shelf-life. The lubricant can be applied by conventional spray, brush and dip techniques.

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Sensemeter Leak Detector

Robinair Manufacturing Corp. is marketing a solid-state electronic leak detector.

The Sensemeter features a sound device that "squeals" in the presence of halogen gas while the meter indicates the leak. The device can detect a leak of ½ oz. per year in one second.

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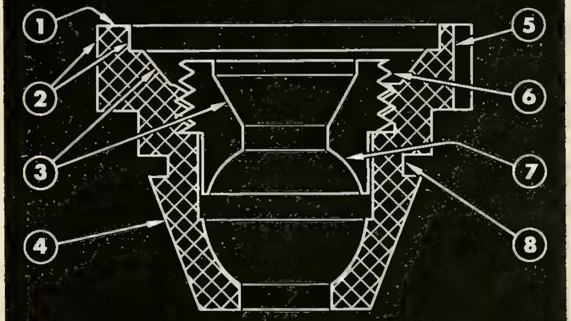
WHAT IS YOUR GRAPHITE SHAPING REQUIREMENT?



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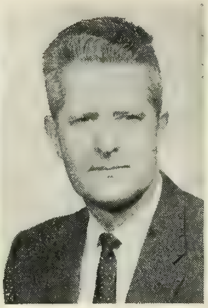
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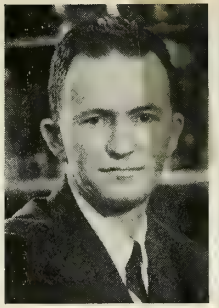
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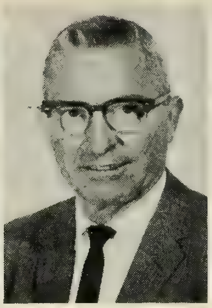
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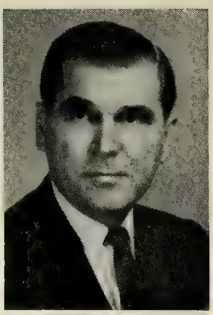

BOETTCHER

Dr. Cameron Knox: Appointed vice president of engineering of Acoustica Associates, Inc., Los Angeles.

A. Raymond Farrell: Appointed marketing manager of the Aerospace Div. of Babcock Electronics Corp., Costa Mesa, Calif.

Eugene C. Ketcham: Named manager of the Contract Administration Dept. at Aeronutronic Div. of Philco Corp., Newport Beach, Calif.

Farno L. Green: Named vice president and general manager of Ex-Cell-O Corp.'s new subsidiary, Viso Corp., Detroit.

Robert H. Denton, Jr.: Appointed manager-market research and planning at Motorola's Chicago Military Electronics Center.

Robert W. Finn: Joined Rocket Research Corp., Seattle, as manager of gaseous bipropellant systems.

John D. Melville: Appointed assistant to the vice president of marketing for the Fenn Manufacturing Co., Newington, Conn.

Edwin W. Templin: Joined D. B. Milliken Co., Arcadia, Calif., as chief engineer.

Henry E. Cooley: Appointed vice president-development and manufacturing operations at International Business Machines Corp.'s Federal Systems Div., Rockville, Md.

Daniel Burr Jones: Appointed a senior psychologist in the Management Systems Div. of Operations Research, Inc., Silver Spring, Md.

Byron K. Boettcher: Appointed Eastern regional manager of Avco Corp.'s Defense and Industrial Products Group and manager of the Washington, D.C., office.

Jack D. Wills: Named product manager-antenna systems at Canoga Electronics Corp., Chatsworth, Calif.

Robert E. Warren: Appointed general sales manager for inertia compensated recorder-reproducers and pressure switches at College Hill Industries, Inc., Warwick, R.I.

Fred R. Sullivan: Elected president and chief executive officer of Walter Kidde & Company, Inc., Belleville, N.J.

Dr. Charles Feldman: Appointed manager of the Physical Electronics Laboratory, Physics Research Dept., at Melpar, Inc., Falls Church, Va.

Douglas D. Danforth: Appointed executive in charge of Westinghouse Electric Corp.'s consumer products group, Pittsburgh. **Robert E. Kirby** named executive in charge of the industrial products group.

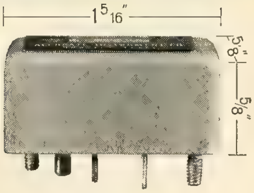
Robert F. Robinson: Named manager of the systems analysis department at Bendix Systems Div., Ann Arbor, Mich.

Douglas A. Worth: Named senior contracts engineer in the Electro-Optical Div. of Perkin-Elmer Corp., Norwalk, Conn.

Richard J. De Cloux: Named vice president of Beede Electrical Instrument Co., Inc., Penacook, N.H.

M. O. Kappler: Appointed vice president of Computer Science Corp., El Segundo, Calif.

NEW!



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—when and where—

JANUARY

Aerospace Sciences Meeting, Hotel Astor, New York City, Jan. 20-22.

American Physical Society Conference on Semimetals, Columbia University, New York City, Jan. 22-25.

SBA-SAVE Value Engineering and Analysis Symposium, Americana Hotel, New York City, Jan. 23.

American Mathematical Society, 70th Annual Meeting, Miami, Fla., Jan. 23-27.

Second Annual Symposium on Fundamental Phenomena in the Materials Sciences, Sheraton Plaza Hotel, Boston, Jan. 27-28.

Conference on Control and System Optimization, Naval Post Graduate School, Monterey, Calif., Jan. 27-29.

AIAA Solid Propellant Rocket Conference, Palo Alto, Calif., Jan. 29-31 (semi-classified).

American Meteorological Society, 44th Annual Meeting, University of California at Los Angeles, Jan. 29-31.

FEBRUARY

American Institute of Chemical Engineers, 52nd National Meeting, Hotel Peabody, Memphis, Tenn., Feb. 2-5.

IEEE Winter Power Meeting, Statler Hilton Hotel, New York City, Feb. 2-7.

International Congress on Documentation and Scientific-Technical Information, Rome, Italy, Feb. 2-11.

International Conference on the Impact of Modern Physics on Materials, Sheraton Hotel, Philadelphia, Feb. 3-7.

IEEE-MIL Fifth Winter Convention on Military Electronics, Ambassador Hotel, Los Angeles, Feb. 5-7.

American College of Radiology National Meeting, Tucson, Ariz., Feb. 5-8.

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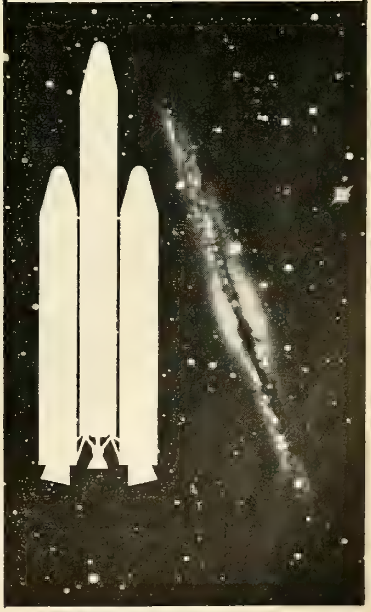

The Incentive Game

ONE OF THE MOST stimulating aspects of the McNamara regime in the Pentagon has been its frank recognition that the profit motive is the spark plug of the free enterprise system.

This has, in fact, gone beyond recognition to open support of the thesis that industry is entitled to fair profit in its work for the Government and that the extent of this profit should vary with such factors as risk-taking and performance.

The profit policies of the Dept. of Defense this year become more critical to industry than ever, with increasing emphasis on incentive contracting and with institution of the mandatory weighted guidelines system, effective on the first of the month.

The weighted guideline system is aimed at establishment of Government profit objectives in negotiated contracts, where price competition is absent or inadequate.

There is still considerable confusion and some question about DOD profit policies. Much of the confusion centers around the weighted guidelines system and its relationship to incentive contracting. The question generally concerns the attitude of the Renegotiation Board to industry profits in excess of the norm.

We present on Page 25 of this issue, together with an article on the subject, a visualization of all this in the form of a game which it has pleased us to call Incentive. Any game-player worth his salt immediately will recognize the kinship between this and Monopoly. The final square, with its question mark concerning renegotiation, smacks all too painfully of "Go Directly to Jail, Do Not Pass Go, Do Not Collect $200."

The risk is similar. Every major company in this business faces the spectre of the Renegotiation Board at the end of each year's contractual relationship with the Government. This is a point on which the industry needs additional reassurance in order for DOD incentive contracts to function as they should.

This is what the executive of one defense firm had to say in an internal memorandum: "We clearly are running the risk of having to repay the Government any substantial 'windfall profits' if we solve all of our problems too quickly."

He advised a course of action for the firm which would "protect reasonable profit rather than open the door to 'windfall profits.' "

He suggested doing this by carefully determining the objectives and work elements, then fully staffing for them—as well as using all of the time budgeted according to the performance level required by the proposal.

"This insures us against future Government claims that our time estimates were inaccurate, and if there are 'breakthroughs,' the surplus time can be applied against related work."

Under the wrong conditions, it is thus apparent, an incentive contract can become a deterrent to performance as well as an incentive.

To understand this, it is necessary to understand what DOD is talking about in its weighted guidelines system and its incentive contracting.

The weighted guideline system is intended to provide Government contracting officers with a numerical guide to use in deciding what a reasonable profit would be. Industry will be expected to use the same guidelines in deciding what its profit objectives are. Differences will be settled at the negotiating table, thus determining the profit dollars to be added to the cost base recognized by the contracting officer.

The weighted guidelines will recognize and reward or penalize for such factors as the contractor's assumption of risk, his investment in facilities, his past performance and other variables.

The system, used to determine the particular profit percentage to be applied to contract cost, is not in itself a direct incentive, although it encourages the contractor to conduct his business in such a manner that he will earn the highest possible profit percentage.

Incentive contracting itself depends upon performance during the life of the contract. This will vary profit percentage, previously determined, within a specified range.

Thus, if the Government and the contractor have agreed through use of the weighted guidelines system upon a profit of 7 percent, the incentive contract may set a range of perhaps 0-14 percent around this, the exact and final amount to depend on performance during the contract. If the contractor achieves a sharp reduction in the cost base, his final profit could, of course, amount to considerably more than 14 percent of the final cost, although it would be only 14 percent of the estimated cost.

It would not be surprising if a profit of, say, 20 percent or more were to raise eyebrows at the Renegotiation Board, even though the net effect was a substantial saving to the Government. But, as every Monopoly player knows, a board is necessary. It is here said to be necessary because factors of judgment play a large role in all of this, despite the application of formulas.

The Defense Dept. itself, in outlining the weighted guidelines philosophy, acknowledges that "pricing by way of cost analysis necessarily involves estimates, and that experienced profits will differ from those contemplated at the time of negotiation and agreement."

FOR THESE REASONS, Mr. Lawrence Hartwig, Renegotiation Board chairman, is on sound ground when he declares that the board must apply judgment in its determinations, not a fixed formula.

But it should be recognized by all three parties—the Board, DOD and the industry—that successful operation of the incentive contracting system depends to a considerable extent on the board's attitude. Perhaps a new statement by the Renegotiation Board that it believes DOD is on the right track would help.

William J. Coughlin

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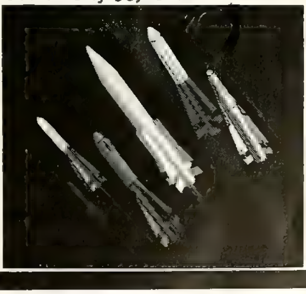

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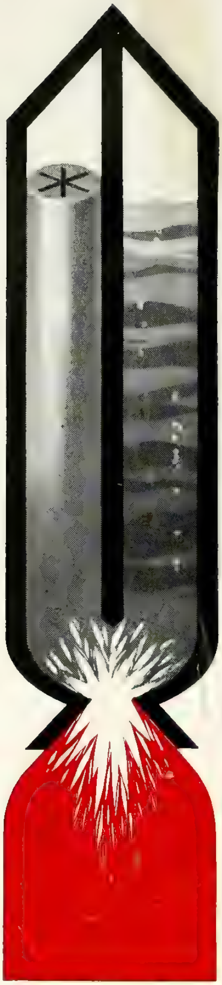

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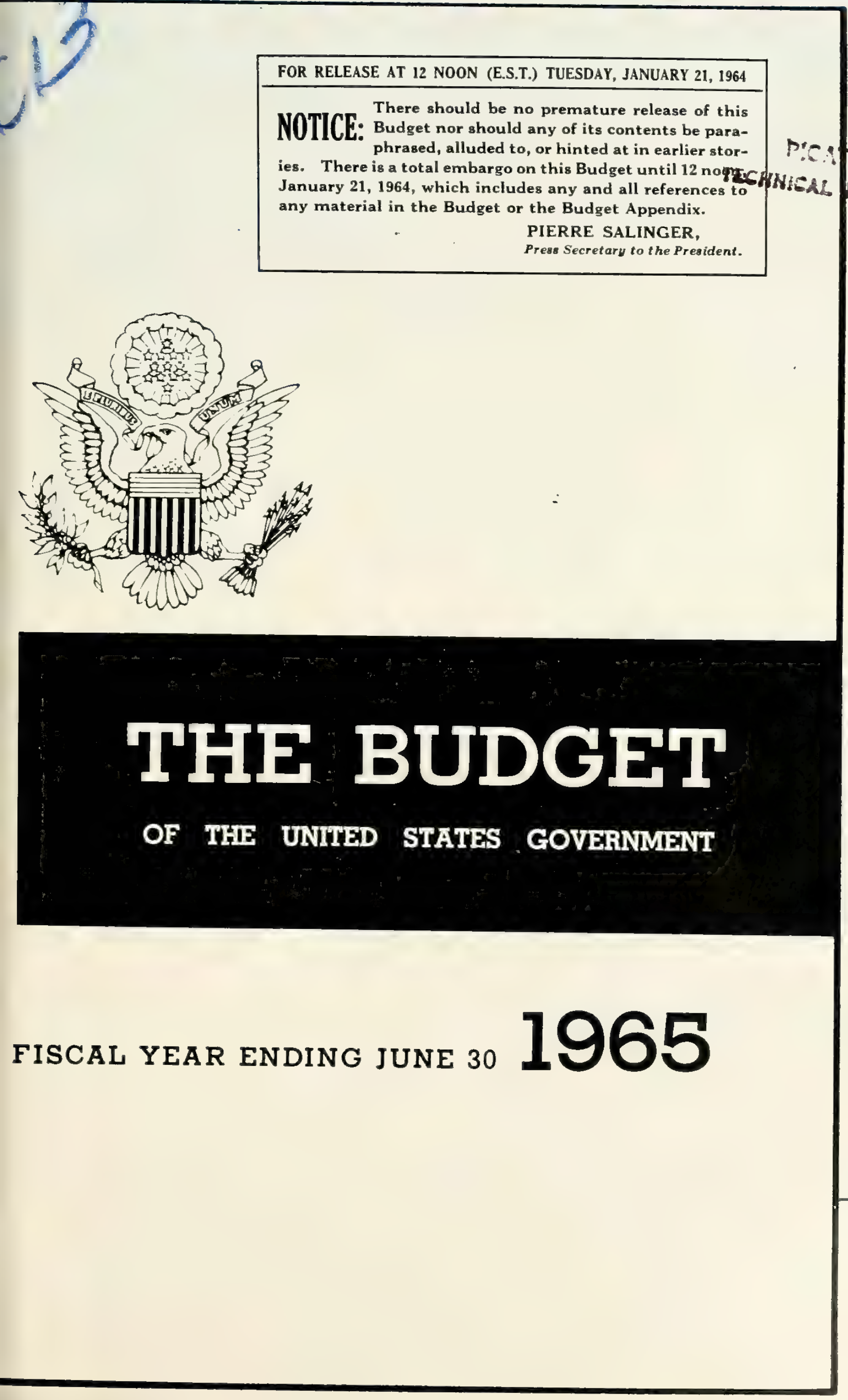
DOD Request Turns Downward

Apollo Schedule In New Jeopardy



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NOTICE: There should be no premature release of this Budget nor should any of its contents be paraphrased, alluded to, or hinted at in earlier stories. There is a total embargo on this Budget until 12 noon January 21, 1964, which includes any and all references to any material in the Budget or the Budget Appendix.

PIERRE SALINGER,
Press Secretary to the President.

THE BUDGET
OF THE UNITED STATES GOVERNMENT

FISCAL YEAR ENDING JUNE 30 1965

PICATINNY ARSENAL
TECHNICAL INFORMATION SECTION

Cover of FY '65 Budget

AN AMERICAN AVIATION
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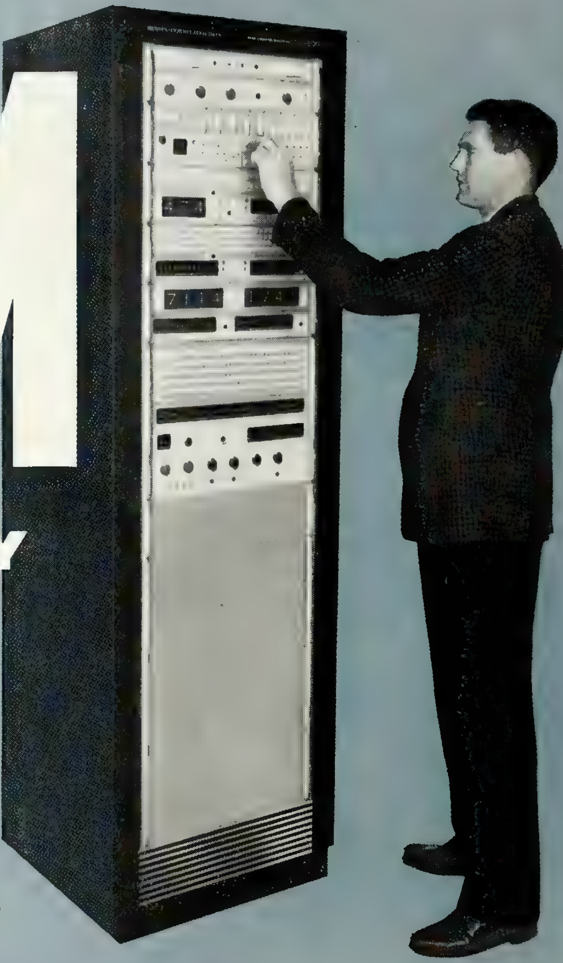
PCM

TELEMETRY GROUND STATION

A BENDIX/CORRELATED DATA PRODUCT



from Bendix-Pacific

The latest from Bendix-Pacific — Model DDS-1000 solid-state Pulse Code Modulation ground station. This is a digital decommutation station capable of demodulating and processing all serial digital information. Outputs are available in a wide variety of serial or parallel digital formats, as well as analog signals for real time visual analysis of data. Flexibility is implemented with self-powered modular sub-assemblies for universal applications, as well as mechanization for special requirements. Silicon semiconductor devices are used throughout the system for high reliability and optimum performance over a wide temperature range.

The DDS-1000 is adaptable to all bit, word, frame, and code formats now in use or planned for the future. The station incorporates an advanced bit synchronizer and signal conditioner for processing serial PCM video signals, as well as a signal simulator for complete self-check. The complete station occupies only a single seven-foot instrumentation rack.

Model DDS-1000 is a development of Correlated Data Systems Corporation and available exclusively from Bendix-Pacific. Contact Bendix-Pacific, North Hollywood, for complete information.

Bendix-Pacific Division THE Bendix CORPORATION

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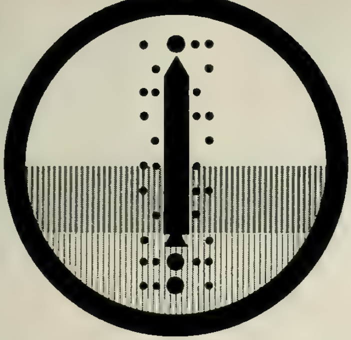
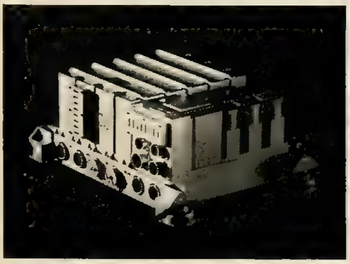
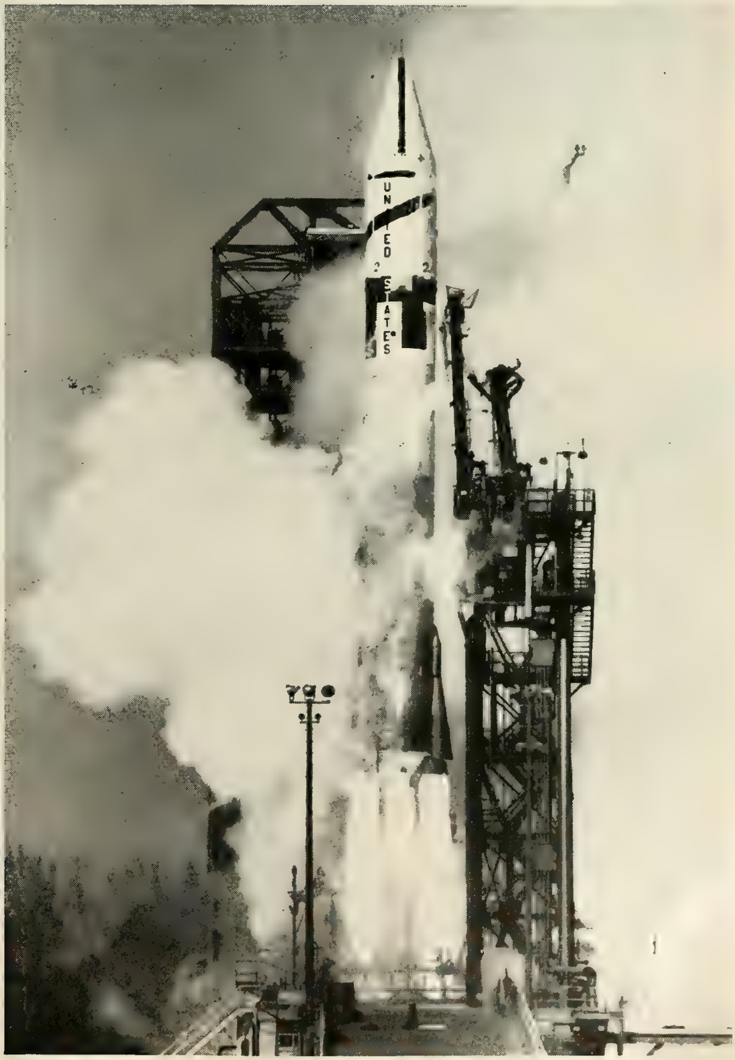


General Precision/Librascope computer guides Centaur

NASA's Centaur spacecraft, the free world's first high-energy space vehicle, is slated to make America's first hydrogen-powered flights with large payloads to the Moon, Venus, and Mars. The powerful Centaur is equipped with a General Precision/Librascope L-31 digital computer as part of its on-board guidance system. This 0.55-cubic-foot computer, weighing only 38 pounds (65 pounds including input-output system), aligns and calibrates the inertial platform; corrects the velocity and distance information for earth oblateness, acceleration due to gravity, and platform accelerometer errors; produces vehicle steering signals and main engine cutoff commands; and furnishes velocity, position, and steering information for transmission to ground control. Whatever your computing or data processing problem, call on Librascope's quarter century of experience in serving major military and industrial projects.

LIBRASCOPE DIVISION
GP GENERAL PRECISION
INFORMATION SYSTEMS GROUP
808 Western Ave., Glendale 1, California





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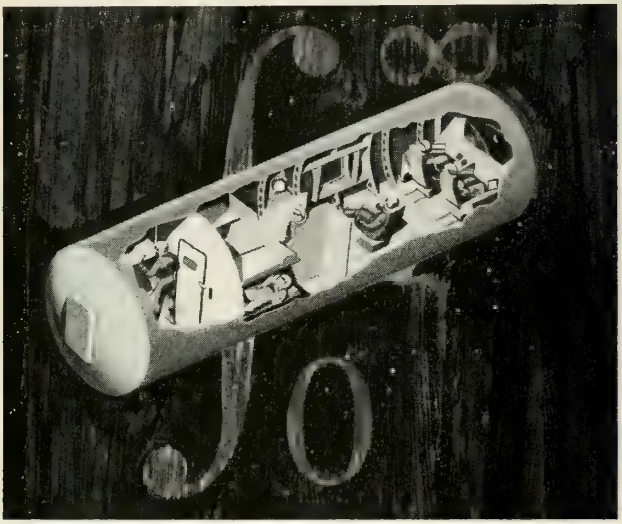
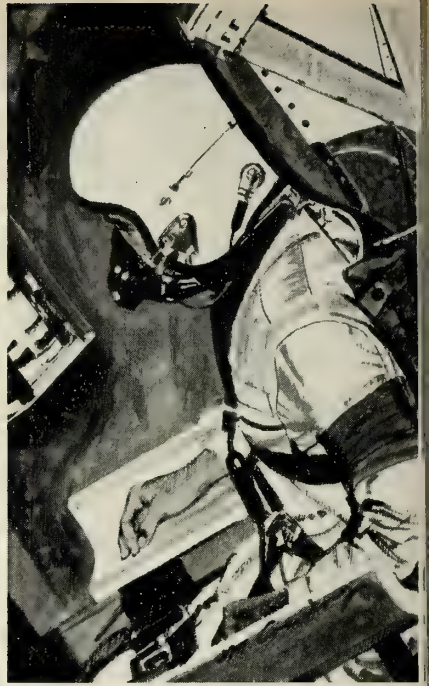
SPINNING-COMPUTING-SIMULATING

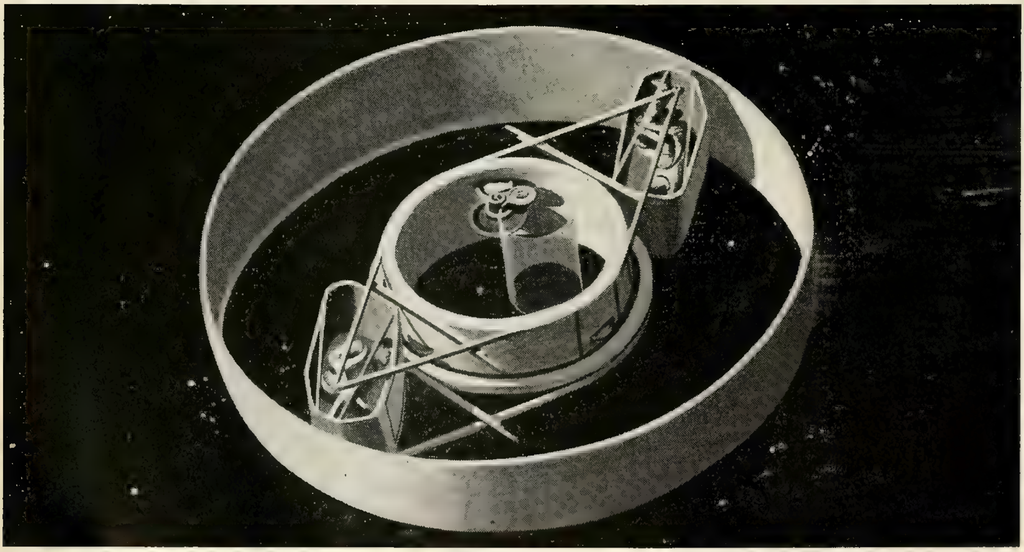
...to ready man for outer space



A MATHEMATICAL SPACE SYSTEM has been built by Douglas to save thousands of hours in building the real one. Computers analyze all the requirements for a complete life support and environmental system, figure out how to satisfy them, and even indicate design details of equipment.



FLYING A SPACE MISSION without leaving earth is one of the functions of the Douglas Bio-Technology Laboratories. Here, the environments of spacecraft cabins are simulated for missions of extended duration to test men and systems. This research provides important information vital to the success of man-rated space voyages.



EXERCISE MACHINE FOR SPACEMEN, this small centrifuge is designed to restore vigor to astronauts weakened by lack of gravity in an orbiting laboratory. Designed and being tested by Douglas, it will be used periodically by members of a space crew and will rotate without disturbing the equilibrium of its space vehicle.

DOUGLAS

MISSILE & SPACE SYSTEMS DIVISION

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missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING
Volume 14, Number 4
January 27, 1964

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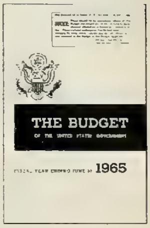

Cover page of President Johnson's Fiscal Year 1965 budget, which went to Congress Jan. 21. Administration request for missiles and space reflects a levelling trend in procurement. M/R's detailed, illustrated report begins on p. 14.

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47,900 copies this issue

The Raven

To the Editor:

Once upon a midnight dreary, while I pondered, weak and weary,
Over the reports and figures I'd been working on since four—
While I nodded, nearly napping, suddenly there came a tapping,
As if someone gently rapping, rapping at my office door.
"'Tis the janitor," I muttered, "come to dust and sweep the floor—
Only this and nothing more."

Ah, distinctly I remember it was early last December.
It was felt that very shortly we would be employed no more.
Every day we feared the morrow; vainly we had sought to borrow
Funds to budget us tomorrow for our work on *Dyna-Soar*—
On the sleek and winged spacecraft that they called the *Dyna-Soar*—
Cancelled now forevermore.

The tapping noises which I mention filled me with a curious tension—
Filled me with an apprehension I had never felt before;
So that now, to still the beating of my heart, I stood repeating,
"'Tis the janitor entreating entrance at my office door—
Just the janitor entreating entrance at my office door—
This it is and nothing more."

Presently my soul grew stronger; hesitating then no longer,
"Sir," said I, "good fellow, truly your forgiveness I implore;
But the fact is I was napping, and so gently you came rapping,
And so faintly you came tapping, tapping at my office door,
That I scarce was sure I heard you," here I opened wide the door—
An empty hall and nothing more.

Long into that hallway peering, long I stood there wondering, fearing,
Doubting, thinking thoughts that I had not allowed myself before;
But the silence was unbroken, and the stillness gave no token,
And the only word there spoken was a whispered *"Dyna-Soar."*
This I whispered, and an echo softly murmured *"Dyna-Soar."*
Merely this and nothing more.

Back into my office turning, as my ulcer started burning,
Soon again I heard a tapping somewhat louder than before.
"Aha!" said I, a minute later, "it's coming from the ventilator!
I'll have a look behind that grate, or this will bug me more and more.
I'll mount a chair, remove that grating and this mystery explore.
A bolt is loose and nothing more."

From off the duct I pulled the shutter, when, with many a flirt and flutter,
Out there flew a stately raven of the saintly days of yore;
Not the least obeisance made he; not a minute stopped or stayed he;
But, with mien of lord or lady, perched beside my office door—
Upon a bust of Eugen Saenger on the bookcase by the door—
Perched, and sat, and nothing more.

Then this ebony bird beguiling my sad fancy into smiling,
By the grave and stern decorum of the countenance it wore,
"This program they have chopped and shaven, but, surely, none would be so craven
As to send a lousy raven to review the *Dyna-Soar*.
Tell me what your need-to-know is, and just what you're looking for."
Quoth the raven, "Nevermore."

Much I marvelled this ungainly fowl to hear discourse so plainly,
Though its answer little meaning, little relevancy bore;
For we cannot help agreeing that no living human being
Ever yet was blessed with seeing on the bookcase by the door
Such a fowl, and, on inquiring what the bird had come there for,
Have it answer "Nevermore."

And the raven, sitting lonely on that placid bust, spoke only
That one word, as if his soul in that one word he did outpour.
Nothing farther then he uttered—not a feather then he fluttered—
Till I scarcely more than muttered, "Hatchet men they've sent before.
On the morrow he will leave me, as our hopes have flown before."
Then the bird said, "Nevermore."

Startled at the stillness broken by reply so aptly spoken,
"Doubtless," said I, "what it utters is its only stock and store
Taught by one who is resistant to a program somewhat distant
Even though we've been insistent *we* know what we're working for—"
From deep within the Pentagon his melancholy burden bore
Of "Never-nevermore!"

But the raven still beguiling my sad fancy into smiling,
Straight I wheeled my swivel chair in front of bird and bust and door;
Then, upon the leather sinking, I betook myself into linking
Fancy unto fancy, thinking what this ominous bird of yore—
What this grim, ungainly, ghastly, gaunt and ominous bird of yore
Meant in croaking "Nevermore."

This I sat engaged in guessing, but no syllable expressing
To the fowl whose fiery eyes now burned into my bosom's core.
This and more I sat divining, with my head at ease reclining
On the cushioned naugehyde lining as the lamplight gloated o'er
The pictures on the panelled wall of TFX and *Dyna-Soar*—
They shall fly—ah, nevermore!

Then it seemed the air got thicker! Was I mad or was I sick, or
Was this raven telling me that they had *cancelled Dyna-Soar?*
"Wretch!" I cried, "who was it sent you? For what purpose have they meant you?
It bodes no good in the event you speak the truth of *Dyna-Soar*.
Don't bother me with rumors wild—we *shall* develop *Dyna-Soar!"*
Quoth the raven, "Nevermore."

"Prophet!" said I, "Thing of evil! Tell me, agent of the devil,
Whether McNamara axed the program or just cut it back some more.
Will he make a presentation to Congress for appropriations?
Does he plan continuation after Fiscal '64?
Is there funding in the budget? Tell me —tell me, I implore."
Quoth the raven, "Nevermore."

"Prophet!" said I, "Thing of evil! Tell me, agent of the devil,
Has this man in Washington whom all of us are working for
No semblance of imagination nor a sense of exploration?
Bitter will be our frustration if our work is truly o'er.
Won't he give our team a chance and reinstate the *Dyna-Soar?"*
Quoth the raven, "Nevermore."

"Be that word our sign of parting, bird or fiend!" I shrieked, upstarting.
"Fly back up into that air duct—to this place return no more.
Leave no black plume as a token of that lie you just have spoken!
Cease this blasphemy you're croakin'—quit the bust beside my door!
Leave me to my charts and figures! Leave this office, I implore!"
Quoth the raven, "Nevermore."

And the raven, never flitting, still is sitting, still is sitting
On the bust of Eugen Saenger on the bookcase by the door.
There he perches, symbolizing efforts at economizing
That succeed in paralyzing Man's desire to explore.
And the sleek and winged spacecraft that they called the *Dyna-Soar*—
It shall orbit—nevermore!

Andy Oberta
Sacramento, Calif.

'Profile of an Industry' Reprints

IN RESPONSE to widespread reader interest, MISSILES AND ROCKETS *has prepared reprints of the three-part "Profile of an Industry" series by Senior Editor William Beller. Based on recent surveys by U.S. Government agencies and the Stanford Research Institute (under a contract from the Aerospace Industries Association), the articles first appeared in the Oct. 28, Dec. 2 and Dec. 16, 1963, issues. Together they provide an unprecedented report on the growth of the Missile/Space industry—now the second largest employer in the Untited States—and its impact on the national economy and technology.*

The twelve-page reprint may be ordered from:

Research Department
Missiles and Rockets
1001 Vermont Avenue, NW
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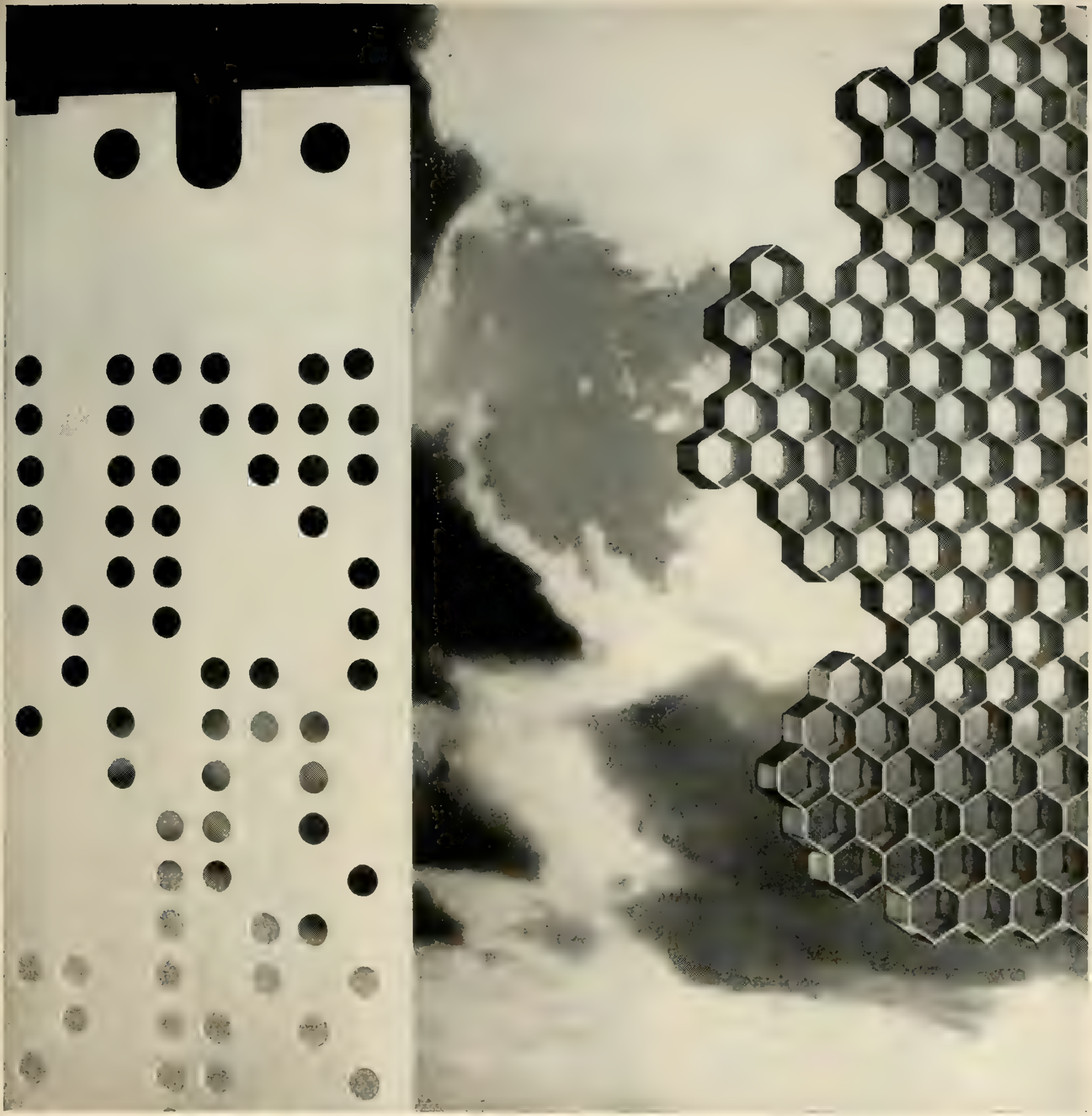
Prices of the reprint is $.50 (fifty cents) per copy.



Program for a mission, pattern for a launcher

Punched cards and aluminum honeycomb played an important part in the development of an advanced ECM simulator, and production of a lightweight launcher for ASROC. While the design problems were different, they were solved by a similar capability—engineering skill and ingenuity offered by Universal Match Corporation's Government Products Group.

A simple punched-card system provides a flexible method for programming the T-4 Electronics Countermeasures Simulator, developed by Reflectone Electronics, Inc., a UMC subsidiary. T-4 can duplicate virtually any RF condition which a B-52 ECM officer might encounter over enemy territory.

Engineers at UMC's Unidynamics Division combined light weight and high strength needed for ASROC's unique launcher through use of honeycombed aluminum. The unit not only nests eight missiles above deck, but also serves as launcher. This imaginative design technique points the way toward more reliable launchers of increased mobility.

UMC's Government Products Group offers the capability for solving many diverse problems, and the ability to design and produce advanced systems important to our defense posture.

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U.S. AIR FORCE BALLISTIC SYSTEMS DIVISION ANNOUNCES NEW FLIGHT TEST PROGRAM OF GENERAL PRECISION SYSTEM

The Guidance and Control Package for 'STAFF'

(Stellar Acquisition Feasibility Flight)

STAFF will provide data on the combined performance of a star tracker and a ballistic missile in the boost phase and in space environment. The special test vehicle, including guidance and control package incorporating the stellar acquisition equipment, is being developed by General Precision Aerospace. "Flight tests of the system, using the Polaris A-1, will be conducted at the Atlantic Missile Range in 1964," said a USAF Ballistic Systems Division Announcement.

General Precision Aerospace has long been a pioneer in the field of celestial-inertial guidance and navigation. In-house and study contracts have led to the successful development of the Star Angle Comparator prototype and advanced instrumentation systems for re-entry vehicles. General Precision Aerospace's responsibility for guidance and control for STAFF is a natural extension of this capability.

Openings now exist on STAFF and applications of this concept for other programs in diverse areas of advanced aerospace guidance.

Qualified professionals are invited to consider these openings at intermediate and senior levels:

SYSTEMS ANALYSIS Specify guidance equations and targeting programs. Investigate dynamics performance of guidance steering loops. Develop digital computer error analysis program.

FLIGHT CONTROL SYSTEMS ENGINEERING Adaptive flight control systems analysis and design for a mobile missile. Duties are concerned with aero-dynamics stability, systems simulations and servo feed-back control techniques.

DIGITAL COMPUTER PROGRAMMING – SPECIAL PURPOSE Develop real time airborne digital computer special purpose programs. Heavy requirements for those experienced in numerical analysis, self-test routines, diagnostic programs, acceptance test programs and time storage estimates.

DIGITAL COMPUTER PROGRAMMING – GENERAL PURPOSE Translation of scientific mathematical expressions into FORTRAN and FAP for computer solution in IBM 7000 series or RPC 4000 machines. Scientific programs involve guidance equations, physical parameters, terrestrial deployment and trajectory simulations, adaptive flight control systems and hybrid guidance systems.

GUIDANCE SYSTEMS INTEGRATION Analysis, integration, and test of prototype inertial guidance systems. Familiarity with performance criteria of stable platforms, digital computers and astro trackers is desirable.

GUIDANCE SYSTEMS DESIGN Develop unique, advanced guidance systems and follow hardware through to test, instrumentation and evaluation. Experience in systems environmental test and performance analysis highly desirable.

DIGITAL SYSTEMS ENGINEERING Systems application and utilization of real time airborne digital computers for stellar inertial guidance systems. Major technical task responsibilities in preliminary systems logic and circuit design. Evaluation of computer development and vendor technical techniques.

FLIGHT TEST ANALYSIS Create and design flight and sled test programs for ballistic missiles and analyze system performance data.

ELECTRO-OPTICAL SYSTEMS Analysis of electro-optical equipment for integration in inertial guidance systems. Requires knowledge of star sensors in digital data handling and signal processing devices.

INERTIAL SYSTEMS ELECTRONICS Analysis and design of sophisticated electronics devices for inertial systems implementation. Requires background in one or more of the following: guidance and control systems, analog computer electronics, network theory, information theory, solid state and micro-miniature circuit design and electronic packaging.

SYSTEMS RELIABILITY Conduct systems reliability data integration, failure and predictability studies. Requiring technical depth in such subsystems as airborne digital computers, inertial guidance platforms and related electronics.

TEST INSTRUMENTATION – AEROSPACE ENVIRONMENTS Design and specify closed servo loop control systems and instrumentation networks for environmental testing programs. Design complete test process control and instrumentation systems for missile-borne stellar inertial guidance and control systems. 5-10 years' experience in instrumentation design and engineering of programmed dynamic test process control. Also thorough knowledge in selection and application of transducers for measurements of environmental and aerodynamic parameters.

ADDITIONAL ENGINEERING OPENINGS:

Gyro Stable Platforms ☐ Servo Test Tables ☐ Microelectronics-Thin Films ☐ Quality Control-Systems ☐ Metrology-Mechanical.

Write Val Metelsky at General Precision Aerospace, Dept. 13-C, 1150 McBride Ave., Little Falls, N.J.

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The Countdown

WASHINGTON

Weather Bureau Settles for Tiros

The low-boiling controversy between NASA and the Weather Bureau over what satellite system the Bureau will fund for operational use is apparently being resolved. The Bureau will use FY '65 funds to order three *Tiros*-type satellites with its own modifications. Engineering details are being worked out.

Elections Put Push Behind Budget

Congress is getting a head start in its yearly hassle with the Federal budget. The House Armed Services Committee already has begun closed-door hearings on the DOD budget and the House Space Committee begins next week. The House is particularly interested in getting the money bills pushed through this year because all its members are up for re-election.

Scientists-in-Balloons Project Still in Works

The Navy-NASA proposal to put groups of scientists aloft in balloons to test operational space equipment is still progressing, though at a slower pace than originally projected. The Navy is taking extra time to map out requirements.

Boston Odds-on Favorite for ERC

NASA will submit to both House and Senate Space Committees on Feb. 1 its report on the need for, and location of, its proposed Electronics Research Center—now believed almost certain to wind up in Boston, where it was originally intended to be. Administrator Webb has made it clear that he favors the Boston location for the $50-million complex. If there's no Congressional action against the proposals by 45 days after presentation, the report will be considered accepted. The initial $5-million funding request for the Center has already been appropriated.

INDUSTRY

New H-1 Ordered for Saturn IB

Saturn IB will get increased booster capability for manned Earth-orbital missions through a more powerful H-1 engine being developed at Rocketdyne Div. of North American Aviation. A joint Rocketdyne-NASA announcement says the new engine—first copy to be delivered early next year—will develop 200,000 lbs. of thrust, compared with 180,000 lbs. for the current H-1 engine in *Saturn I*. Eight of the new H-1's will give *Saturn IB* total thrust of 1,600,000 lbs. Estimated extra cost is $5,000,000. A stainless-steel tubular wall thrust chamber, a redesigned turbopump, and modifications to valves and ducting will be incorporated in the new engine, which will use the same propellant combination, RP-1 and LOX.

Titan III Program Cost Holds Tight

Total face value of the *Titan III* program has increased only one-third of one percent during the first 10 months of the 3½-year program. When all contract negotiations presently in hand are definitized, increase will amount to approximately 1.2% of original space values, says Maj. Gen. Ben I. Funk, commander of Air Force Space Systems Division. The *Titan III* program is operating 98% on incentive contracts.

'Lidar' Device for Orbit Checks

Satellite orbits may be determined with extreme accuracy with use of "Lidar," a laser mounted with a photocell detector on a gun mount so that it may be aimed easily. NASA plans to test the concept with a satellite equipped with corner reflectors. The reflectors have very precisely made right-angle corners to reflect an intercepted beam back toward its source.

Value-Engineering Payoffs Reported

Value-engineering clauses have been inserted by the Air Force Space Systems Division in some 75 contracts with total face value of $1.3 billion. To date, SSD reports, it has effected value engineering savings of $16.1 million, of which $2 billion has so far passed audit. It credits industry with initiating value-engineering actions which called for contract changes producing a potential saving of $3.4 million thus far.

Lunar Seismograph May Spot Nuclear Tests

Columbia University's Lamont Geological Observatory predicts a "major breakthrough" in underground nuclear test detection may be obtained with a permanent seismic station to be located two miles deep on the ocean bottom 150 mi. west of San Francisco. Lamont will install and operate the station under contract to ARPA. Heart of the station will be a modified version of a compact seismograph developed at Lamont for operation by remote control on the Moon.

Perkins New Head of AIAA

New president of the 30,000-member American Institute of Aeronautics and Astronautics is Prof. Courtland D. Perkins, Chairman of the Dept. of Aerospace and Mechanical Sciences at Princeton University. He succeeds Dr. William H. Pickering of Jet Propulsion Laboratory. Perkins, a former Air Force chief scientist, is also chairman of the NATO Advisory Group for Aeronautical R&D, succeeding the late Dr. Theodore von Karman, and vice chairman of the USAF Scientific Advisory Board.

INTERNATIONAL

Japan To Launch Bigger Lambda

Japan plans to launch a two-stage *Lambda III* this year as part of its participation in the International Year of the Quiet Sun. The new space observation rocket will be more powerful than *Lambda II*, launched last Dec. 11 from Tokyo University's Kagoshima Space Center on Kyushu. The new vehicle is among nine research programs being conducted by the Japanese during the IQSY. Others include terrestrial magnetism, cosmic-ray studies, solar activities, and the ionosphere.

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The Missile/Space Week

Ranger, Saturn Set To Go

NASA plans two major space flights this week. *Ranger VI* is to be launched on a hard-landing lunar photographic mission and the *Saturn SA-5* with an Earth-orbital capability.

Ranger VI will be sent aloft with an *Atlas-Agena* from Cape Kennedy no earlier than Jan. 30. The 804-lb. spacecraft will carry six television cameras to photograph the lunar surface. The pictures are to provide support data for the soft-landing *Surveyor* and the *Apollo* manned lunar landing.

If successful, the *Ranger VI* will send back the first space photographs of the Moon since those of the Soviet's *Lunik III* in October, 1959. Five previous *Ranger* launches were unsuccessful.

Ranger's planned trip to the Moon will take about 66 to 68 hours. During the last 10 minutes of flight, cameras will take more than 3,000 photographs. The craft will then crash on the Moon's surface at a velocity of 6,000 mph. No other scientific experiments will be aboard.

The first complete *Saturn* vehicle will be launched from Cape Kennedy no earlier than Jan. 27. The *SA-5* will be the first of the Block II series, in which the second stage is "live," and is capable of placing more than 20,000 lbs. in Earth-orbit.

The S-1 first stage will be powered by eight H-1 engines, each producing 188,000 lbs. of thrust. The second-stage S-IV is powered by six RL-10A3 engines, with a total thrust of 90,000 lbs. The S-IV, being flown for the first time, burns a liquid hydrogen/liquid oxygen combination.

Shots of the Week

The Air Force scored two successes with its *Minuteman* "Instant ICBM" Jan. 16, one from Cape Kennedy, the other from Vandenberg AFB, Calif. The Cape Kennedy shot was a test of devices in the warhead designed to confuse enemy defenses. The Vandenberg shot was described as a routine training launch by a Strategic Air Command crew.

- NASA's *X-15* rocket plane was flown Jan. 16 in a test to determine if sharpening the leading edge of the craft's vertical stabilizer would reduce re-entry heating.
- NASA fired a series of five *Nike-Apache* sounding rockets from its Wallops Island, Va., launch site Jan. 15-16 bearing sodium vapor payloads. The agency used cameras to record wind direction and velocity as indicated by the vapor clouds.
- The Navy successfully launched a *Polaris A3* Jan. 20 from a surface ship cruising off the Florida coast. The success was the 20th in 32 firings of the missile.
- The Air Force on Jan. 19 launched a *Thor-Agena* carrying a secret satellite. Firing was from Vandenberg AFB, Calif.
- *Relay II*, NASA's communications satellite, was set into orbit Jan. 21 with a *Delta* rocket (see p. 36).

USSR To Join in Echo Tests

NASA Deputy Administrator Hugh L. Dryden has announced Russian plans to cooperate with the U.S. in radio and optical experiments involving the *Echo* balloon satellite, which was to have been launched late last week.

The possibility that Russian scientists will also join in *Echo* radar experiments still exists, but the Soviet Union has not made any commitment as yet in that area.

The move was the first on the part of Russia to implement the U.S.-Russian space cooperation agreement signed last summer. Other details of the plan have been bogged down in technical disagreements between the two countries.

Gemini-Titan II Firing a Success

A highly successful sequence compatibility firing of the *Gemini-Titan II* booster Jan. 21 at Cape Kennedy has raised hope that the first manned *Gemini* flight will still take place in 1964.

Charles W. Matthews, *Gemini* project manager for the Manned Spacecraft Center, admitted that delays in making the static test had cost some time, but said effort will be made to bring the program back on schedule.

Matthews added that the flight readiness firing, normally made after the stages are assembled vertically, will be eliminated because the static firing test met all pre-launch requirements.

The first and second stages were mounted side by side, and engines of each stage were run at full 500,000-lb. thrust for 30 sec. Total firing time was 60 sec. The stages, linked by cable, fired in sequence as they will in actual flight.

A full 300-min. countdown was run to permit insertion of a full propellant load, and final checks of electrical, propulsion, and guidance systems were made as though it was allocated in the countdown for checkout of an imaginary spacecraft and insertion of two astronauts.

Areas checked during the static test included engine gimballing, propellant pressurization, engine shutdown methods, propellant flow rates, electrical system verification and operation of the malfunction detection system.

Strike Looms at Cape

Labor peace that has existed at Cape Canaveral-Cape Kennedy for the past three years may soon end with 11,000 to 12,000 building trades and industrial union members leaving their jobs.

Cause of the impending walkout is the planned turnover of railroad operations on the Cape and Merritt Island to the Florida East Coast Railroad after construction of tracks is completed on March 2.

The railroad was struck by 11 non-operating unions on Jan. 23, 1963, but has continued to move freight trains on a limited basis through use of supervisory personnel.

The railroad company recently completed a $3.5-million project to link Merritt Island with the mainland by a causeway across the Indian River. The work was done at the railroad company's expense with an agreement the firm would be permitted to operate trains on the government reservation to serve the MILA industrial and launch areas and the Air Force *Titan III* complex.

International representatives of several trades met at a recent AFL-CIO convention in New York City and pledged support to the striking railroad men. Speculation is that this would bind the local unions to observe picket lines if and when they appear and indications point to such action if the railroad company does start running all trains to Merritt Island and the Cape.

Martin, TRW Form New Firm

Bunker-Ramo is the name of a new jointly owned electronics firm announced late last week by Martin Marietta Corp. and Thompson Ramo Wooldridge, Inc.

Martin Marietta president George M. Bunker will represent that company's controlling interest in the new enterprise as chairman of the board. Dr. Simon Ramo, vice president of TRW, will serve as president.

TRW will contribute the physical assets of its Computer Div. at Canoga Park, Calif., and plans to transfer ownership in computer operations in France, England and Japan to Bunker-Ramo.

Bomarcs Being Retired

Early (A) models of the *Bomarc* air defense missile are to be dismantled by the end of 1965 according to the Defense Dept.

The 150-mi.-range missiles have been in operational status at Dow AFB, Maine; Suffolk County AFB, N.Y.; McGuire AFB, N.J.; Otis AFB, Mass.; and Langley AFB, Va., since 1959.

Senate To Study ICBM Reliability

Sen. John C. Stennis (D-Miss.), chairman of the Senate Preparedness Subcommittee, has announced plans to bring "up to date" that body's information on the U.S. ballistic missile deterrent.

The decision is viewed as a direct outgrowth of a recent charge by Sen. Barry Goldwater (R-Ariz.) that this country's ICBM's are "undependable."

Sen. Goldwater suggested at the time of his missile statement that a Senate investigation be conducted into the matter. Sen. Stennis, however, stressed that the subcommittee study does not herald definite plans for a formal investigation.

'Outer Space' Definition Sought

The New York law firm of Hyman, Hayman and Harris has received from an Air Force scientist a definition of the demarcation line between Airspace and outer space.

Office of Aerospace Research scientist Norman Sissenwine, speaking strictly in technical terms, stated that "the lowest altitude at which . . . the line of demarcation should be drawn is 100 kilometers."

Hyman, Hayman and Harris sought the counsel of Sissenwine in attempting to make a legislative interpretation on the point for the Congress of the International Astronautical Federation and the International Institute of Space Law.

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LBJ Asks for $16.38 Billion

PRESIDENT JOHNSON has sent to Congress a sharply pruned Fiscal Year 1965 missile and space budget calling for $16.383 billion, down more than $1 billion from last year's record funding level of $17.9 billion.

The missile/space request fell victim to a heavy cutback in missile procurement, a reduction in Dept. of Defense space spending, a leveling off of NASA's budget and completion of the *Polaris* submarine-building program.

With an election year approaching and tax-cut legislation pending, it may be in for further rough seas as it moves through Congress.

While the Fiscal '65 budget request marks the first downturn since 1961, the picture could brighten in Fiscal 1966.

DOD officials report that a decision on development of the *Nike-X* anti-ballistic missile program—at a total cost of $12-20 billion—may be made in calendar '64. If approved, first hardware development funds for the program would be included in the budget presented to Congress in January of next year.

At the same time, sufficient funding has been requested in FY '65 for a start on a real development program for the Air Force's *Manned Orbiting Laboratory* project.

With a total cost estimated at from $1 to $3 billion, it is earmarked for FY '65 funding of just under $100 million.

This will probably mean selection of a prime contractor in 1964 as well as increased military space spending in the future.

The major reason for the slashed FY '65 request is the cutback in missile funding for both procurement and research, development, test and evaluation.

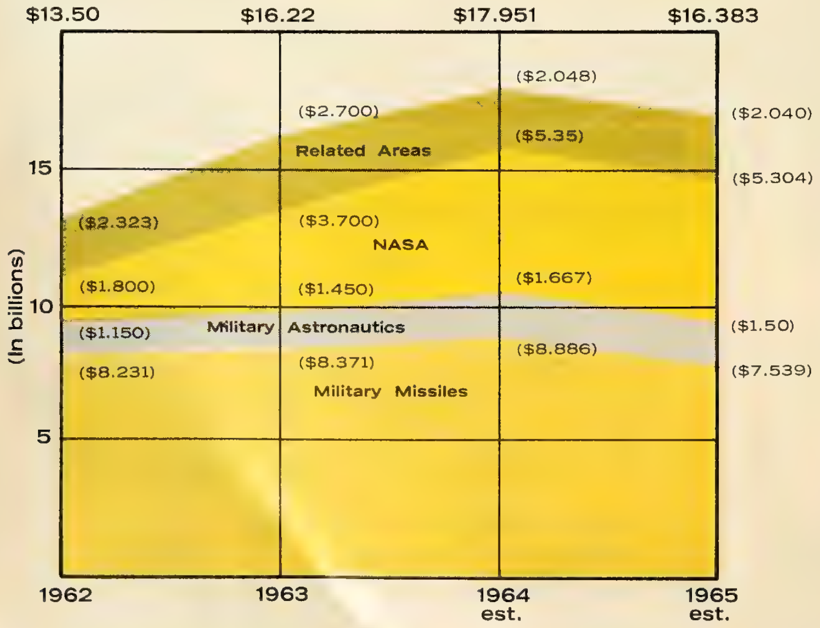
Total obligational authority for missile procurement was reduced from $3.865 billion to $2.988 billion as *Atlas* and *Titan II* procurement in any significant volume ended in FY '64. The major new missile buy will be for 50 more *Minuteman II* silos, which will increase the *Minuteman* force from 950 to 1,000. More of the long-range missiles will also be purchased as the Air Force begins to replace the earlier *Minuteman I*. Missile RDT&E also dropped from $2.526 billion to $1.851 billion.

Completion of the *Polaris* submarine-building program—budgeted at $750 million—also was a major reason for the budget reduction for the next fiscal year. Procurement of *Polaris* missiles, however, will continue.

- **Space Budget**—The overall administration space budget was also sharply reduced from last year's $7.666-billion level to just about $7.1 billion.

The major factor was the reduction of NASA's budget from the $5.7 billion requested last year to $5.304 billion. The agency total includes $4.382 billion for research and development, $641 million for administrative operations and $281 million for construction.

The DOD space budget was cut by some $140 million to about $1.5 billion. The request last year was for some $1.667 billion. Reportedly, however, DOD officials reduced this to $1.615 billion during the year by re-programming and assessing Congressional cuts.



MISSILE/SPACE FY '65 BUDGET REQUEST

(in millions of dollars)

Missile Procurement	2,988.0
Missile RDT&E	1,851.0
Missile Maintenance	2,000.0
Missile Base Construction	700.0
NASA R&D	5,023.0
NASA Construction	281.0
Military Astronautics	1,500.0
AEC Astronautics	200.0
Weather Bureau Astronautics	37.0
NSF Astronautics	3.0
Associated Electronics	550.0
Military Science, Foreign Sales and Military Assistance	1,250.0
TOTAL	16,383.0

Cut in ICBM Buying Lowers Request

McNamara to spell out further details this week; a breakdown by services; funding up in some areas and Nike-X may lie ahead

DEFENSE SECRETARY Robert S. McNamara was scheduled to lay before Congress this week the details of a $52.4-billion budget request for total obligational authority in Fiscal 1965.

Administration spokesmen, with eyes cocked toward the Hill and the electorate, stressed that the FY '65 budget marked the first downturn in requests since the Kennedy Administration took office three years ago.

The decline showed in two other key budget categories—the request for new obligational authority, and estimated expenditures. The general downturn reflected itself in turn in a net reduction in requests for research, development, test and engineering.

At the root of the trend, as one DOD spokesman pointed out and McNamara had stressed earlier, is the sharp reduction in the huge capital outlay expenditure for new missile systems over the past several years. One effect of this is the cutback in RDT&E funding because, as the spokesman pointed out, the current family of ICBM systems are in the "final and less expensive" stages of testing and evaluation.

• **Nike X factor**—However, he pointed out, calendar 1964 could see a decision on whether or not to produce *Nike X*. This is "possible" in the coming year, but would be too late to affect the FY '65 budget. It is "not clear" whether there will be a basis from incoming test results and other information for the Administration to make the decision for Fiscal 1966.

Total obligational and new obligational authority requests were down slightly, $28 and 120 million respectively. The DOD reduction in actual spending estimates compared with FY 1964 was $1.1 billion, down to $51.2 billion, including $1.2 billion military assistance.

Administration spokesmen said that the funding level for the Air Force's *Manned Orbiting Laboratory* would be slightly below $100 million for the initial stages of the program. The *ASSET* program was expected to be well above the $8.5 million FY '64 level.

The military space R&D program, including certain related procurement, was expected to be funded at about $1.5 billion, according to Administration sources.

For missile procurement, the three service requests for total obligational authority amounted to $2.988 billion. (Total obligational authority means new obligational plus residual authority DOD is requesting from prior years.)

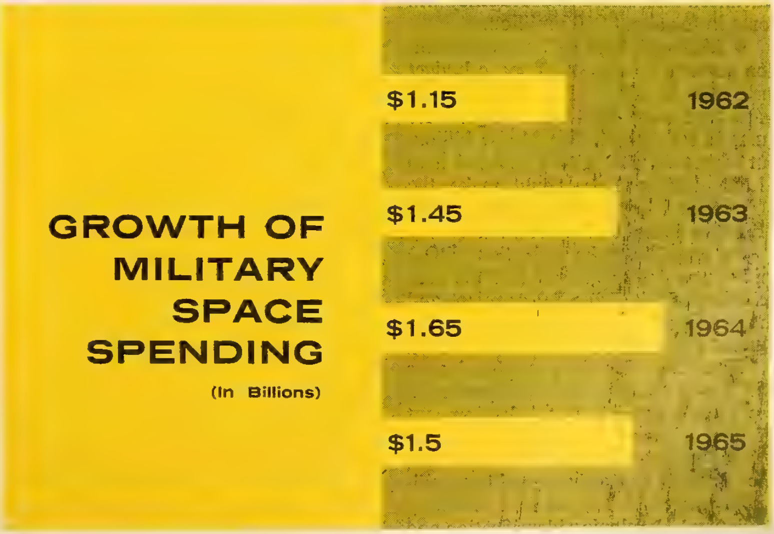
• **By services**—Significant breakouts for ballistic missiles, other missiles, modifications, spares, and other support, were (in millions):

—*Air Force:* $947.7; $110.0; $232.6; $67.0; and $524.4, the last including a number of important classified projects.

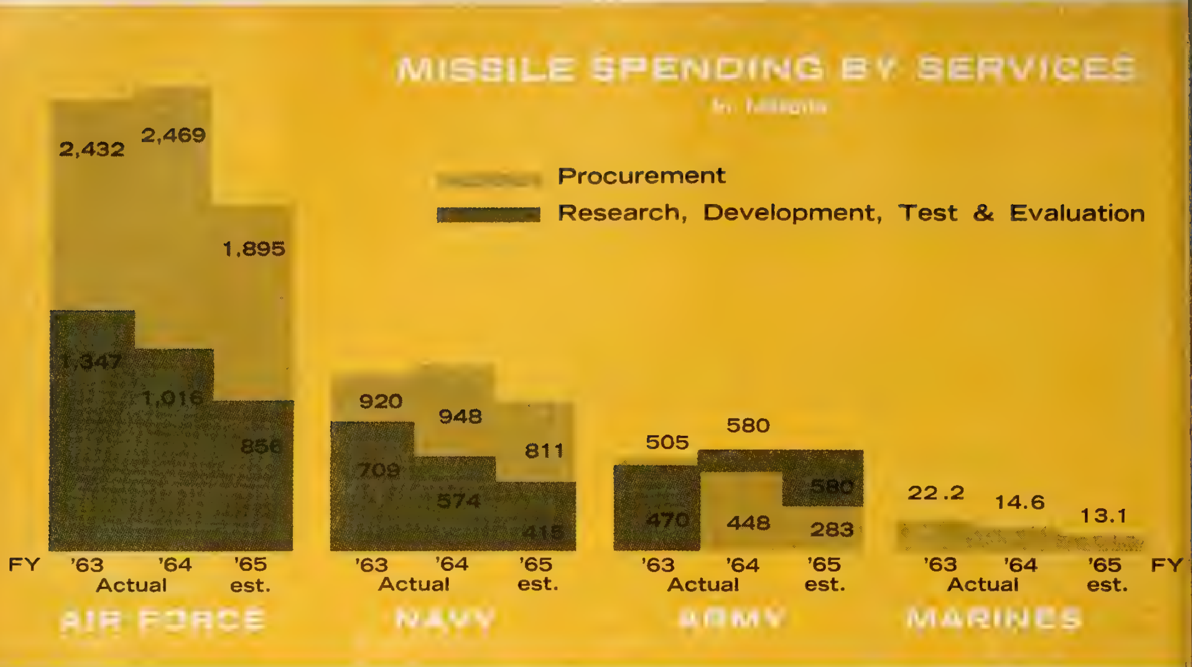
DOD spokesmen said the Air Force will increase the *Minuteman* force to 1,000 missiles, will replace one squadron of *Minuteman I* with the much-admired *Minuteman II*, and plans to retrofit the *Minuteman I* silos to accommodate *Minuteman II* in the future.

—*Navy:* $423.1; $296.1; $4.1; $5.3; $21.4. In addition to *Polaris*, Navy will continue procurement of *Tartar, Talos, Terrier, Sparrow, Sidewinder, Shrike* and *Bullpup* missiles, the latter four also on the Air Force's list. The Navy will also buy its new *Subroc* submarine-launched ASW missile.

—*Army:* $258.6 million for all mis-


GROWTH OF MILITARY SPACE SPENDING

(In Billions)



siles, plus $24.0 million for spares. Army plans initial *Lance* and *Shillelagh* procurement, and *SS-11* antitank buys for helicopter mounting.

In RDT&E, missiles accounted for total obligational authority of $1.851 million, down from $2.169 last year. Of this total, *Nike*-X will gain a substantial increase over last year. The *Mobile Medium Range Ballistic Missile (MMRBM)* will also gain funding. Also in the works is continued *Lance* development, and work on a new ship-to-air missile system for the Navy.

Project Defender elements in the Advanced Research Project Agency will come in for about $100 million.

- **Military Space**—The $140-million cutback in the DOD space budget marks the first time it has taken a downward turn since 1961. The original request in FY '64 was for $1.667 billion, but reportedly DOD later reduced it to $1.615 billion. This would make the FY '65 total for space spending about $1.475 or just about $1.5 billion.

In explaining the reduction, DOD said it was possible because of the cancellation of the *Dyna-Soar* project and the peaking of *Titan III* funding in the current fiscal year.

The funds for the next fiscal year will pay for continued development of the *Titan III*, the first real development of the *Manned Orbiting Laboratory (MOL)* using the *Gemini-X* spacecraft, the *Transit* navigation satellite, military communication satellites, tracking equipment, developing identification and interception capability and experimental *Nuclear Detection Satellites.*

Increased funds will also be spent on research on re-entry vehicles and lifting bodies.

- **Military Construction**—Funding of major construction projects in the Air Force, Army and Navy totals almost $1 billion, with a large portion involving missile/space projects.

The Air Force budget for major items totals $359.9 million in total obligational authority. One of the big projects will be the construction of silos and related buildings and equipment for one additional hardened-site *Minuteman* squadron. Money is also included for increasing survivability through improvement of facilities for the previously authorized *Minuteman* squadrons and improvement of the *Titan* missile sites.

Funding for the Army's major construction items totals $371 million, much of it devoted to structures to provide site relocations, additions and improvements for the *Nike-Hercules* air-defense missile and further work to protect the system against radiation.

A major portion of Army construction for research and development will be devoted to facilities for development of the *Nike-X*. Other important Army projects provide for a missile system calibration laboratory at Redstone Arsenal and land purchase at White Sands.

Navy funding will total $256.2 million. Part of it will pay for construction for the *Polaris* missile system, which will contribute to the "operational readiness" of the system. ■

Budget Terms Explained

What the Administration terms its Direct Budget Plan corresponds to Total Obligational Authority (TOA). This is the total cost of a program planned in connection with the particular fiscal year. This sum comes for the most part from Congressional authority to commit funds in that year and, in small part, from obligational authority granted in previous years, but under which funds were not committed.

New Obligational Authority (NOA) is the amount asked from Congress after financial adjustment to allow for funds already authorized in previous years but not yet expended.

Obligated Funds represent contracts to be let in a given year, although the money itself may be disbursed in later years. Money actually to be spent in a given fiscal year is listed as Expenditures. This consists of funds obligated in that year or in earlier years for that year.

Most NASA figures emphasize NOA; DOD is inclined to stress TOA.

Apollo in Trouble Despite Increase

TWO NEW FLIGHT PROGRAMS and a sharp rise in Project *Apollo* spending are included in NASA's FY '65 budget of $5.304 billion despite a slight drop from the agency's FY '64 $5.35-billion authorization level.

A total of $2.6 billion in R&D funds has been requested for the manned lunar landing program, including $945.8 million for the spacecraft and $988.4 million for the *Saturn* booster.

This is more than $400 million above the FY '64 budget of $2.2 billion. The three-man space flight project will also receive another $141 million if Congress approves the space agency's supplemental appropriation bill for the current fiscal year.

The two new flight programs, an *Advanced Technology Satellite* and the new *FLOX Atlas* tests, are ticketed for a total of $48.5 million.

- **New program details**—A contractor for the satellite project—which will be used to test equipment for communication, weather and navigation satellites—will be selected within the year. A total of $31 million has been requested for the flight series, with $29.9 million for the spacecraft and $1.1 million for supporting research and technology.

Funding of the new *FLOX Atlas* program will jump from $1.9 million in FY '64 to $17.5 million in the next fiscal year as the space agency moves toward two new flight tests of the fluorine/oxygen mixture in the booster. Most of the funds will go to the launch vehicle's prime contractor, General Dynamics/Astronautics, and the engine contractor, Rocketdyne Div. of North American Aviation, Inc.

The large increase in funding of *Apollo,* however, may not be enough to prevent the program from slipping into the 1970's. Space agency officials have declared that Congress must approve the FY '65 budget and FY '64 supplemental request if the U.S. is to meet the goal of landing a man on the Moon by the end of this decade.

- **Apollo in jeopardy**—In an election year, Congress is unlikely to heed this warning and some reduction in the request is almost certain. In addition, the ever-present technical problems that have delayed this country's other manned spaceflight programs, *Mercury* and *Gemini,* are expected to play havoc with the *Apollo* schedule.

NASA's FY '65 budget was presented to Congress by President Johnson Jan. 21. It included $4.382 billion for research and development, $281 million for construction and $641 million for administrative operations.

(For other details of the agency's funding request, see page 19 in this issue, and M/R, 1/20/64, p. 14.)

In addition to manned spaceflight, the only other R&D area showing a major increase is the lunar and planetary program, which rises from $270 million to $300.4 million. The heavier funding is accounted for by development funds for the *Lunar Orbiter* program, $49.3 million; *Surveyor,* $136 million; and the *Pioneer* solar probe series, $21.1 million.

Partially offsetting was a sharp cutback in the *Ranger* program—$52.2 million to $10.8 million. The *Mariner* interplanetary spacecraft program budget was also reduced slightly from $59.1 million to $54.1 million. ■

BREAKDOWN OF FY'65 MAJOR NASA CONSTRUCTION

(In thousands of dollars)

PROJECTS BY LOCATION	FY 1965
AMES RESEARCH CENTER	**$ 6,085**
Administrative management building	1,451
Flight simulator for advanced aircraft	2,630
Instrument building extension	1,996
ELECTRONICS RESEARCH CENTER	**$ 10,000**
Center support facilities	1,950
Electronic components laboratory	3,200
Engineering and administration building	1,850
Qualification and standards laboratory	3,000
GODDARD SPACE FLIGHT CENTER	**$ 1,300**
Earth albedo and infra red simulation system for the space environment simulator	500
STADAN engineering and real time station	400
Relocation of Wallops Island training facility	400
JET PROPULSION LABORATORY	**$ 3,714**
Addition to spacecraft development engineering building No. 233	564
25-Foot simulator modification	2,350
Supporting services building—(Edwards Test Station)	400
JOHN F. KENNEDY SPACE CENTER, NASA	**$ 91,261**
Addition, manned spacecraft checkout building	16,316
Advanced Saturn launch complex No. 39	63,284
Extension to central supply complex	952
Manned spacecraft static test facility	2,780
Propellant systems components laboratory	588
Utility installations—New area	5,600
Modifications to Centaur launch complex No. 36	451
Modifications to launch complex No. 17	465
LANGLEY RESEARCH CENTER	**$ 4,454**
Thermal control housing and building addition for dynamics research laboratory	801
Fatigue research laboratory	1,221
Central high pressure air supply	2,077
LEWIS RESEARCH CENTER	**$ 810**
34.5–138 KV Electrical Power Substation	810
MANNED SPACECRAFT CENTER	**$ 25,166**
Modification to environmental testing laboratory	9,416
Electronic systems compability facility	4,110
Lunar mission and space exploration facility	2,647
Central data facility extension	2,658
Technical services facility	2,240
Flight crew operations facility	1,764
MARSHALL SPACE FLIGHT CENTER	**$ 15,288**
Extensions to Saturn V ground support equipment test facility	2,495
Cold flow test facility	2,368
Extension of components test facility instrumentation	1,814
Extension to the propulsion and vehicle engineering laboratory	2,230
Saturn support test area	3,206
MICHOUD PLANT	**$ 6,534**
Facility additions to support Saturn S–IB and S–IC production	2,735
Alterations to Saturn first stage production facilities	628
Central computer facility extensions and alterations	1,160
MISSISSIPPI TEST FACILITY	**$ 61,991**
Additional utility installations and support facility	9,533
Components service facility	5,499
Saturn V first stage (S–IC) static test facility	26,384
Saturn V second stage (S–II) static test facilities	20,575
VARIOUS LOCATIONS	**$ 37,597**
Facilities for F–1 engine program	2,707
Facilities for J–2 engine program	10,971
Facilities for S–II stage program	2,024
Facilities for S–IVB stage program	10,709
Facilities for M–1 engine program	3,970
Addition to space radiation effects laboratory for added capabilities	1,876
Apollo network ground stations—new stations	4,010
Apollo network ground stations—additions	1,330
WALLOPS STATION	**$ 1,804**
Launch area modification	684
Support facilities	1,120
ALL LOCATIONS	**$ 15,000**
Facility planning and design	15,000
TOTAL	**$281,000**

FY '65 Budget–

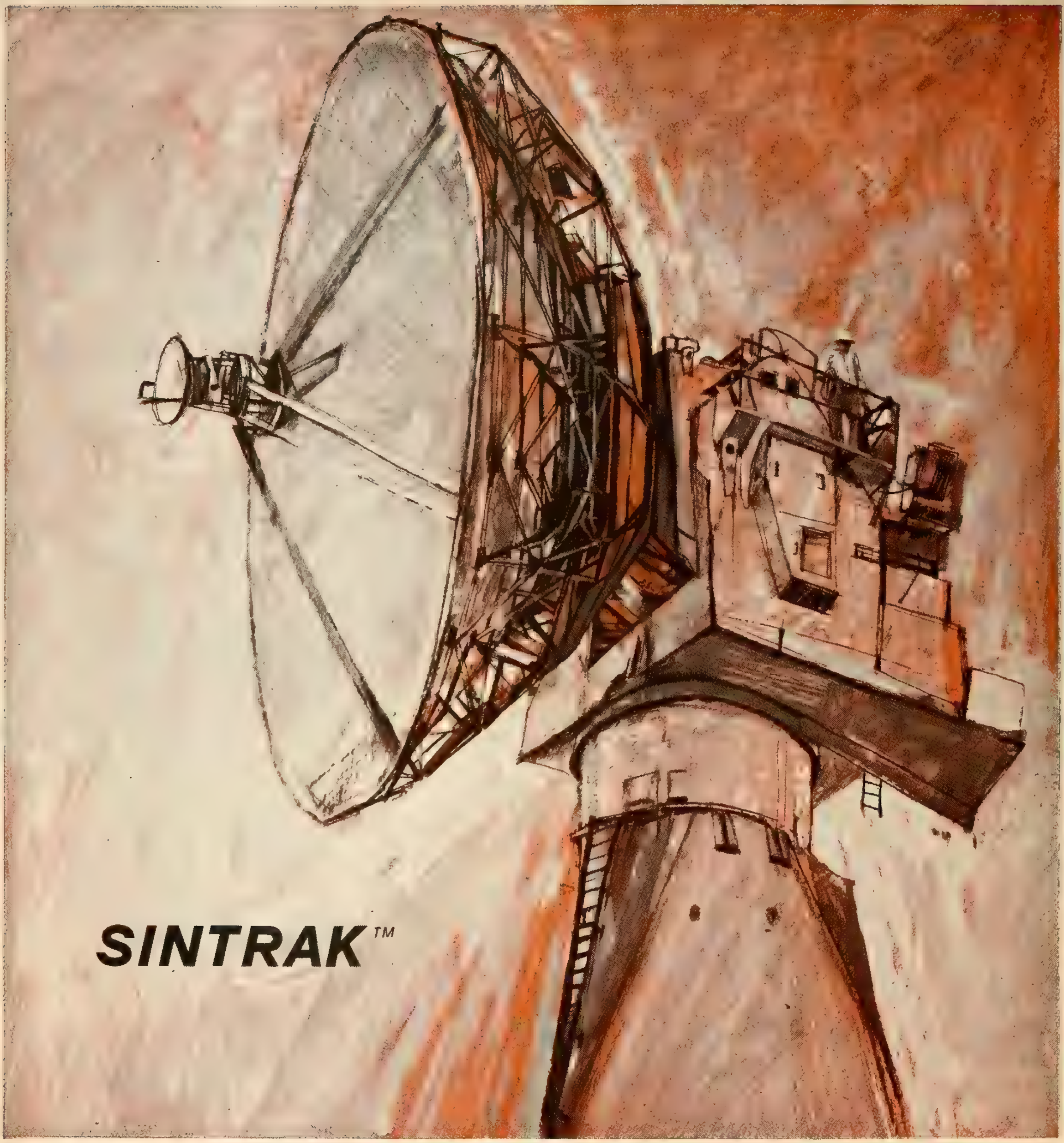
DEFENSE

ATLAS	Procurement complete. Thirteen squadrons to be reduced to nine.
TITAN I	Procurement complete. All 54 missiles operational through 1965.
TITAN II	Production, installation and checkout continues. Number of squadrons increasing fro 12 to 16.
TITAN III	Development continues. R&D peak in '64; therefore, funding drops.
MINUTEMAN	Additional buy of 50 Wing VI missiles requested. Total Minuteman program is 1,0 missiles (200 Wing VI). Others will be purchased as replacement of Minuteman Funding declines at FY '65.
POLARIS (MISSILES)	A-1, -2 procurement completed. A-3 procurement continues with Navy budget of $4 million for Polaris missiles and related equipment. Low-level funding for studies of advanced sea-launched ICBM.
DYNA-SOAR	Cancelled in calender year 1963.
MOL	Development continues with slightly less than $100 million in FY '65.
AADS-70	Studies continued.
ASROC	Procurement continues.
BMEWS	O&M funds for support of three sites.
BULLPUP	Procurement by AF and Navy of improved version continues. Procurement of Bullpu training missile will continue.
DAVY CROCKETT	Procurement complete.
DEFENDER	Support continues at $100-million level.
FALCON	Procurement of various advanced models continues.
FIREBEE	Procurement on used basis continues.
HAWK	Program complete except for addition of limited anti-tactical ballistic missile capabilit
HONEST JOHN	Procurement complete except perhaps for limited funds to maintain a production cap bility; a new warhead to be procured and improvement program will be initiated.
HOUND DOG	Procurement complete.
LANCE	Development continues; first procurement will be initiated in FY '65.
LITTLE JOHN	Procurement complete.
MAULER	Development continues; procurement delayed by development problems.
MMRBM	Development continues at higher level than FY '64.
NIKE-HERCULES	Program complete except for addition of limited anti-tactical ballistic missile capabilit
NIKE-ZEUS	Development will continue as part of overall Nike-X program. Development fundir "significantly higher" than the $246-million requested in 1964. Decision on progra go-ahead may be made in calendar '64 with funds included in FY '66 budget.
NIKE-X	
PERSHING	Procurement continues.
REDEYE	Procurement initiated by Army and Marines with latter's budget at about $13 million.
SATELLITE INSPECTOR	Development continues.
MILITARY COMSAT	Development funding essentially the same as FY '64.
SERGEANT	Procurement complete.
SHRIKE	Procurement by both Navy and AF continues.
SIDEWINDER	Procurement of 1C version continues by Navy and AF.
SPACE SURVEILLANCE	Development of SPADATS and Satellite Interceptor continues.
SPARROW	Procurement of III version by AF and Navy continues.
SPRINT	Development continues as part of the missile mix for the Nike-X system.
SUBROC	Procurement continues.
TALOS	Procurement of improved version continues.
TERRIER	Procurement of improved version continues.
TARTAR	Procurement of improved version continues.
TRANSIT	Replacement satellites for operational system to be procured. Improvement progra continues.
TYPHON	Development of shorter range version continues.
PHOENIX	Development of long-range missiles for TFX continues.
SS-11	Procurement continues for employment on Army helicopters.
REDHEAD ROADRUNNER	Procurement continues.
SHILELLAGH	Procurement initiated in FY '65.
TOW	Development continues.

Programs at a Glance

NASA

GEMINI	Funds drop from $383.8 million to $308.4 million, including $168.9 million for the spacecraft and $111.3 million for the Titan II and Atlas-Agena launch vehicles.
APOLLO	Funds jump from $2.244 billion $2.678 billion. Spacecraft program will get $945.8 million in FY '65 and $31 million in FY '64 supplemental appropriation request.
LUNAR LOGISTICS VEHICLE	No development funds will be provided. Studies to continue.
MANNED ORBITING SPACE STATION	No development funds. Studies will continue.
ADVANCED MANNED MISSIONS	Funds for studies of space stations, lunar base and manned interplanetary flight projects increase slightly to $26 million.
SATURN V	Funds jump by almost one-third from $689.6 million to $988.4 million. In addition, the project will receive $110 million in the supplemental FY '64 request.
SATURN I	Termination of last four flights means a cut from $204.2 million to $120.6 million.
SATURN IB	Funds increase by more than $100 million to $260.1 million as booster moves toward its 1966 launch date.
LIQUID ROCKET ENGINE	H-1 engine funding drops to $9.8 million, RL-10 engine to $17.9 million. Request for F-1 increases to $64.1 million and J-2 engine to $61.6 million, M-1 engine to $25 million.
SOLID ROCKET ENGINE	260-in. motor program transferred to NASA from DOD. Will be funded at $13 million.
LARGE LAUNCH VEHICLES	No funds requested. Studies will continue.
SCIENTIFIC OBSERVATORIES	Orbiting Solar Observatory funds down from $14.7 million to $13.1 million. Other projects include Advanced Orbiting Solar Observatory, $9 million; Orbiting Astronomical Observatory, $51 million; and Orbiting Geophysical Observatory, $55.4 million.
EXPLORERS	Funding for small scientific satellites drops from $34.2 million to $31.9 million.
RANGER	Funds drop sharply from $50 million to $10.8 million as five spacecraft are cut.
SURVEYOR	Sharp increase in development funds to $136 million as the program moves toward its first flights in 1965.
MARINERS	Funding drops from $59.1 million to $54.1 million.
LUNAR ORBITER	New project will be funded at $49.3 million.
PIONEER	Slight increase in solar probe program from $17.7 million to $21.1 million.
CENTAUR	Budget request drops from $108.1 million to $92 million.
FLOX ATLAS	Sharp increase from $1.9 million to $17.5 million as space agency plans two flights to test fluorine/oxygen mixture.
SCOUT	No development funds. Procurement money included in other projects.
DELTA	No development funds. Procurement money included in other projects.
SOUNDING ROCKETS	$15 million for scientific sounding rockets. Weather sounding rocket budget increases from $2.9 million to $3 million.
BIOSATELLITES	Budget request increases from $8.5 million to $19.2 million.
WEATHER SATELLITES	Funds drop sharply from $67.8 million to $37.5 million, with $18.9 million for Nimbus, $5.8 million for Tiros and $3.2 million for Synchronous Meteorological Satellites.
COMMUNICATIONS SATELLITES	Slight decrease from $13.5 million to $12.6 million, with $300,000 for Echo, $1.8 million for Relay, $2 million for Syncom and $5 million for a gravity gradient test.
ADVANCED TECHNOLOGICAL SATELLITES	New flight project budgeted for $29.9 million.
BASIC RESEARCH	Funding remains at FY '64 level of $21 million.
SPACE VEHICLE SYSTEMS	Budget reduced from $49 million to $38.8 million, with $26.3 million for supporting research and technology, $3 million for small flight projects, $2 million for Scout reentry tests, $2.6 million for the Micrometeoroid Detection Satellite, and $3 million for Project Fire.
SNAP 8	Funds increased from $15.5 million to $18 million.
SERT	Budget increased slightly to $5.1 million.
NERVA	Budget drops from $52 million to $34.5 million.
SPACE POWER	Research funds remain at $13 million.
ELECTRONIC SYSTEMS	$28.4-million budget includes $25.4 million for supporting research and technology, and $3 million for small flight projects.
HUMAN FACTORS SYSTEMS	Funding request of $16.2 million includes $13.2 million for supporting research and technology, and $3 million for small flight projects.
TRACKING AND DATA ACQUISITION	Funds increase from $210 million to $267.9 million, including $152.6 million for equipment and components, $99.8 million for network operations, and $15.5 million for supporting research and technology.



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Ground R&D Stressed, Flight Trimmed

NEW BUDGET figures show that the Atomic Energy Commission has ordered a slowdown and critical appraisal of the Satellite and Small Power Systems program—still referred to as *SNAP*, after its earlier designation, Systems for Nuclear Auxiliary Power.

Total astronautics figure for the AEC is about $199 million, with nuclear weapons programs at $771.8 million and military reactor systems at $111.7 million (including ground-based systems).

While the astronautics figure is very close to that for Fiscal Year 1964, items in the budget reflect an emphasis on ground research and a cutback in flight programs.

AEC officials indicated at a budget briefing that *SNAP 10A* (0.3 KW) and *SNAP 2* (3 KW) are being re-evaluated in terms of whether flight testing should ever occur. Even if flights are made, the officials said, "we will not go ahead in full form."

• **SNAP cutbacks**—*SNAP 2* has been cut to a base effort and has no program funds in the FY '65 budget, compared with $8.5 million in the current year. "The program is in question," AEC officials said. "There is no outstanding mission now."

The smaller *SNAP 10A* has been cut from $15 million in FY '64 to $8.6 million in FY '65. Flight program also is under evaluation, AEC said.

Only *SNAP 8* apparently will progress at full steam. The 35-KW flight reactor program will be increased to $16 million, compared with $11 million in the current fiscal year.

AEC has decided to stretch out the *SNAP 50* program, which is to provide power from 300 KW to 1 MW. "The decision has been made to proceed slowly," a spokesman explained. "It amounts to a change in emphasis in the program." *SNAP 50* has been cut about $5 million from the previous year, to $17 million in FY '65.

However, the approach to *SNAP 50* will be the same as originally planned, AEC officials stressed. The hardware will just be delayed in coming. The spokesmen also said that the decision to stretch out the program was not based upon NASA information.

• **Rover**—The agency has inaugurated a significant step-up in an advanced, higher-power graphite reactor program (Phoebus). From $7.8 million during the current fiscal year, the AEC has jumped to a request for $17.5 million for FY '65. In fact, the total advanced research and technology budget has almost doubled, from $14.8 million in the current year, to a requested $27.8 million for FY '65.

The Kiwi program, as expected, has only $1 million, since the program is being phased out. Funding in the current year is $14.2 million.

NERVA engine funding has been cut back from almost $54 million in the current year to $48 million for FY '65. Rocket station operations increased slightly, from $7 million to $8 million.

AEC officials confirmed recurrent rumors that the Rover program has been cut to a ground-based, research and engineering effort only. "The flight program definitely has been deferred until we have a firmer mission and have better demonstrated what we can do." Both NASA and AEC officials testified that "If we have good progress this year, we could start RIFT (reactor-in-flight tests) in the early 1970's."

• **Pluto slashed too**—The AEC also is asking for $3 million in obligational authority for research and development test plants for Rover at Los Alamos and about $6 million for plant and general equipment. This brings the Rover total to $93 million.

The *Pluto* missile propulsion reactor falls quite short of the current year's funding level of $14 million, with $8 million asked for FY '65. AEC said that this program is about to wind up, and that future developments depend upon user agencies.

Pluto efforts during FY 1965 will consist of completing the Tory II-C tests and some concurrent work on components for a high-temperature reactor. This work, said AEC, will lead to a better basis for evaluation by potential users on what their requirements are.

A medium-power reactor at Oak Ridge, which might have some space research applications, will be funded at $4 million for FY 1965. In addition, AEC allots a certain percentage across the board in advanced space research and technology. The FY '65 figure is $199 million. ■

FY '65 BUDGET/WEATHER BUREAU

Bureau Buying 3 Tiros-type Satellites

THE WEATHER BUREAU will order three operational meteorological satellites of a modified *Tiros* type with Fiscal '65 funds, although launch may come in a later calendar year.

The Bureau's meteorological satellite group will seek to spend $35.3 million on its operational satellite program in Fiscal '65, and $2.325 million in associated research.

The agency's funds—found in the Dept. of Comemrce budget—will call for only $18 million in new obligational authority for operations, since more than $17 million is left over from previous authorizations.

As expected, there are no funds for *Nimbus* in the total of $26.8 million for spacecraft and launching. The satellite center already has announced that it will embark upon an intermediate meteorological system based upon *Tiros* technology, rather than the more expensive *Nimbus* to which it was first committed.

Capital outlay for command and data acquisition will drop to $2 million, from $4.76 million last year, and data-processing, analysis and archiving funding will remain at the same $500,000 level.

In actual operating costs, the group will seek $9.68 million, compared with $6.55 million in FY '64. While total costs add up to almost $39 million, excluding R&D, nearly $4 million of this is already in stock. Thus, actual expenditures for this year are only $35.3 million. ■

For gun-launched missiles . . .

16-in. HARP Booster Nears Flight

by Michael Getler

NEW YORK—First flight tests of a new 16-in. rocket motor to be used to boost 100-lb. vertical-gun-launched payloads to altitudes of 1,000 mi., or 1,000-lb. payloads to 300,000 ft., is expected in May at the U.S. Army-McGill University (Montreal) Project HARP test complex at Barbados Is., British West Indies.

Static tests on the engine, being developed by Canadian Arsenals Ltd. in Valleyfield, are under way.

In addition to vertical flight capabilities, project sources say, use of multiple staging with the engine would allow placement of 50-70 lb. payloads into a 60-100-mi. Earth orbit.

Though satellite launching is not now an announced requirement under HARP (High-Altitude Research Probes), it is known that initial feasibility calculations have been completed and show that satellites could be placed in orbit with rocket-boosted gun launchings and guidance problems do not appear "too difficult."

Under HARP, McGill Univ. and the Army, with technical and contractual responsibility lodged with the Ballistics Research Lab (BRL) at Aberdeen Proving Ground, Md., have teamed up to use several different bore-diameter guns to vertically launch a family of non-rocket-assisted and rocket-boosted missiles to high altitudes for scientific research.

The program has expanded greatly in the past 12-18 months. Some 70 vertical firings have been made, mostly engineering development flights, and about 60% have been successful.

• **Growth potential**—Despite its direction towards atmospheric research, there has been considerable speculation that the program may grow further. Apart from the obvious economies involved in a perfected system, allowing other nations to launch probes and satellites inexpensively, it might find a role in an anti-satellite or A-ICBM system.

The latter possibility is based primarily on HARP's very high launch velocities, which eliminate low-altitude wind problems and permit very close impact prediction. Guidance problems in some of these situations depend to a large extent upon the range and type of warhead used.

First details on HARP, and its possible evolution into defense systems, were reported by M/R last summer (July 1, 1963, p. 18).

Spending on the program is now said to be approaching $1 million annually, up from about $50,000 less than 2 years ago, according to informed sources. Army support is said to total about $800,000, with a slight increase expected in FY '65. Some outside agency support is also probable. Interest has also been expressed by Greece, Argentina, Egypt, Britain and France.

Successful firing of the new 16-in. motor could lend impetus to extending application of these techniques beyond HARP objectives. The new launch vehicle will be the next generation in the McGill *"Martlet"* missile series, but will drop the *Martlet* designation.

• **Firing plans**—The May test series will include some 30 firings from the 16.4-in. gun. In addition to the shots with the 16-in. motor, first tests of new versions of earlier *Martlet*-series missiles will be made. *Martlet 2* vehicles, not rocket-assisted, will be test-fired using a new gun propellant expected to yield muzzle velocities of 6,000 ft./sec., lifting a 180-lb. vehicle over 100 mi. The rocket-boosted *Martlet 3B*, also to be fired for the first time, is 2 in. wider than its predecessor, the 6-in-dio. *3A*, and uses a steel airframe rather than aluminum. A 5,000-ft./sec. muzzle velocity is hoped for, with a 200-mi. altitude capability for a 45-lb. payload. Total launch vehicle weight is reportedly about 240 lbs., and the vehicle costs about $1,000. Smaller-diameter missiles fired from the 16-in. gun use wooden sabots to guide them down the barrel.

Also in the offing are first firings with new 7-in.-dia., very long gun barrels now being mounted at Aberdeen. These are expected to undergo horizontal test firings next month and first vertical firings in April, probably from NASA's Wallops Island station. In about 6 months, the 7-in. gun could be moved to Barbados to take part in a dual gun experiment in which the 16-in. gun places about 100 lbs. of chemicals at 250,000 ft. and the 7-in. gun fires a series of electron-density measurement probes.

Whereas firings made earlier in the HARP Project verified performance of a gun system without rocket boost, the first rocket-assisted firing was made in September at Barbados using a 170-lb. *Martlet 3A*. Four tests were made; two reportedly were perfect and two unsuccessful due to sabot failures.

In the tests, the *3A*, which carries 50 lbs. of N-5 propellant (case-bonded to a 7-in. body) with a 5-sec. burning time and specific impulse of 200 sec., glided for 14 sec. after gun launching to an altitude of 30,000 ft., where the rocket motor was ignited. The muzzle velocity was 3,180 ft./sec. and a velocity increment of over 3,000 ft./sec. at motor ignition was observed by phototheodolite cameras.

• **Recent series**—Dr. Gerald V. Bull of McGill University in Montreal and Charles H. Murphy of BRL, who reported on the September launchings at the American Institute of Aeronautics and Astronautics meeting in New York last week, also told M/R about the latest series of firings in the gun-launched missile program just completed in mid-January.

This series of 16 shots, including both *Martlet 2* and *3A* launchings, was especially significant in that it marked the first operational receipt of telemetry signals from the vertically fired vehicles, and also first use of a scientific payload with the 16-in. gun at Barbados (other experiments with smaller-bore guns have been carried out in HARP).

The telemetry system, provided by Computing Devices of Canada, involved hooking up a sub-carrier oscillator to a pressure transducer in the rocket engine to measure pressures during burning. The signal was received over the 250-mc band by Army ground vans and also by the Twin Falls Victory tracking ship, off-shore for a portion of the flights. Telemetry was being received to the 300,000-ft. altitude and survived 3,750 ft./sec. muzzle velocities and launch g's estimated at about 6,000.

Transmitters of 1,680 mc are under development for improved range and angle data telemetry for ground stations.

Included in the just-completed series of *Martlet 2* flights was an AF Cambridge Research Lab experiment in which tri-methyl-aluminum and sodium were carried aloft. The 2 lbs. of TME was released at 70 km and upwards and combined with atomic oxygen so that photo stations could gather data on upper wind profiles. ■

HIGHLY QUALIFIED PROPULSION ENGINEERS

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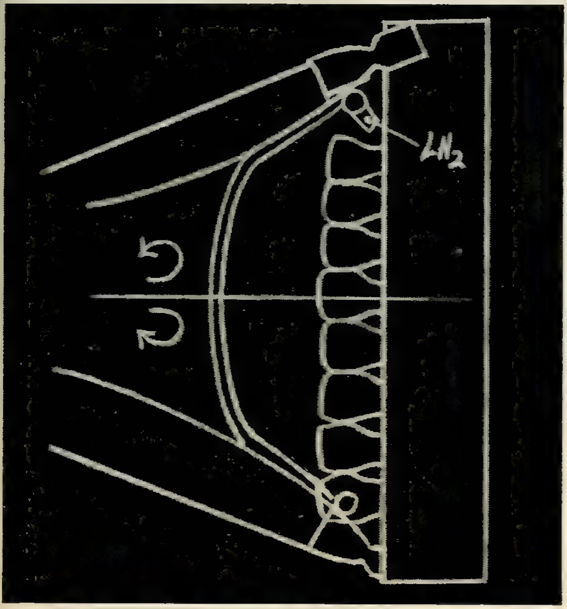

An annular cluster of engines is used to form a truncated plug nozzle. How do we provide efficient cooling of the plug under varying engine conditions and during engine-first re-entry from orbit?

WITH ASSOCIATES LIKE THESE...

R. H. Michaelis is currently responsible for propulsion system design and analysis for advanced launch vehicles. Previous assignments include studies of manned lunar landings, orbital propellant storage, and high energy upper stages; the design of various Saturn S-IV propulsion subsystems; and the deployment of Thor IRBMs in England.

Mrs. M. L. Williams is presently conducting research on advanced propellants and combustion. Her background includes 13 years of experience with U.S. Naval Ordnance in the fields of physical chemistry, propellant process development, and propellant research. She is a member of ReSA, an Associate Fellow of AIAA and the author of many technical papers.

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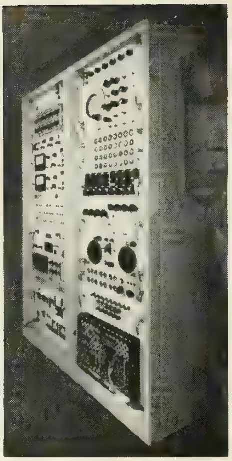

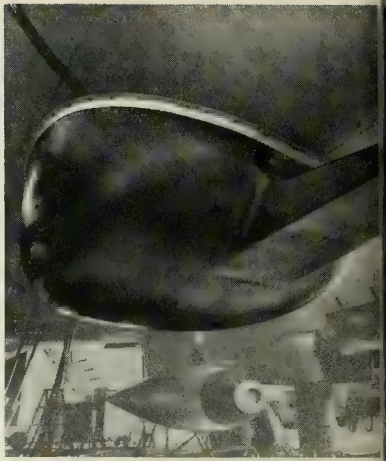

These systems were diverse, incompatible, inharmoni

Integrating an avionic system is a little like commanding a United Nations army.

Each subsystem speaks its own language. Each must do its work in its own way, co-operate with all the others but not interfere with them. The babble of tongues from the input systems must be translated into computer language. The computer must analyze and evaluate their intelligence, then issue commands. The commands must be transl into another set of languages for the output systems.

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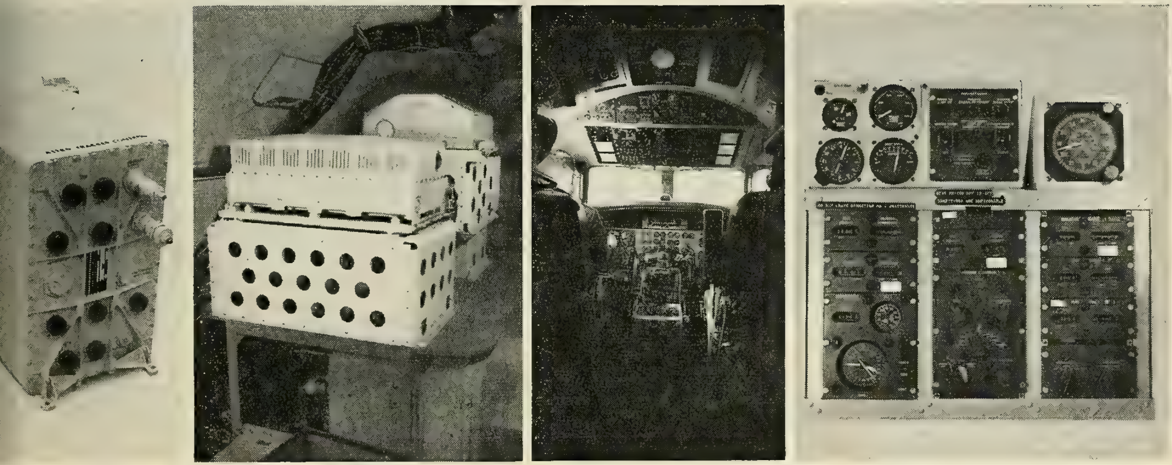

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Technical Countdown

ELECTRONICS

Electronics Market to Double by 70's

The constant-dollar value of military and space electronics shipments is expected to double between 1961 and 1970—from $5.5 billion to $10.7 billion, according to a U. S. Dept. of Labor estimate. The anticipated growth rate in shipments for this product category is higher than that for any other major product category, but most of the expansion is expected to occur before 1965. Value of total electronics shipments, in constant 1960 dollars, is expected to reach nearly $20 billion by 1970. This is a rise from $10.8 billion in 1961.

Apollo Motion Simulator Proposed

Development of a 23-ft.-dia. spacecraft dynamic motion simulator capable of unlimited angular motion has been proposed by Westinghouse to NASA. A 34-in.-dia. scale model already has been built for the Houston Manned Spacecraft Center and soon will be placed in operation to prove conceptual feasibility. The simulator, conceived for use with *Apollo*-size vehicles, employs six sets of steerable dual aircraft wheels, driven and steered by hydraulic motors. By fixing the wheel assemblies to the spacecraft mounting superstructure, the entire system can rotate within a cup-shaped hemispherical base. Pilot control actions are signalled to a computer that in turn provides the control for proper drive and direction to the outer wheels.

MINS Touted for Dual Capability

Kearfott claims a dual application for its Miniature Inertial Navigation System. A non-fluid-filled MINS stable platform, for aircraft use, will withstand up to 70 g's, while the fluid-filled version for missiles will survive over 100 g's, the General Precision, Inc., division asserts.

Detector Aids IR-Laser Beam Study

Kodak IR Phosphor, a new infrared detector, has been used by scientists at Eastman Kodak Co. to show location and rough distribution from IR lasers operating in the 0.7 to 1.3-micron range. The device provides a convenient method also for determining the shape or size of the far-field pattern at various distances from the laser rod. The phosphor detector is coated on white paper and laminated between 2 x 3-in. sheets of Tenite. Precharged with ordinary fluorescent-lamp white light, the phosphor emits an orange light when hit by the laser beam. The beam pattern on the phosphor can be photographed for record.

Hot Spots in the Atmosphere

Peculiarities in the upper atmosphere, possibly having profound effects on the Earth's weather, can be detected by infrared instruments aboard a weather satellite or spacecraft. This conclusion is part of a NASA-funded study aimed to test out a new physical principle proposed by the Geophysics Corp. of America calling for a "mathematical analysis of imbedded atmosphere heat sources." The company says the theory should lead to meteorological inferences of a number of atmospheric variables not presently taken into account either in weather forecasting or in meteorological studies of other planets. Some of these "inaccessible variables": concentration and distribution of water vapor, carbon dioxide and ozone; zones of atmospheric instability; the pressure at the surface or tops of clouds.

SPACE MEDICINE

NASA Documents 100% Oxygen Apollo Choice

Choice of a 5-psi, 100% oxygen environment is documented by Edward L. Michel, George B. Smith, Jr., and Richard S. Johnston of NASA's Manned Spacecraft Center in the December Journal of Aerospace Medicine. They rate it above 7-psi, 50/50 oxygen-nitrogen in weight, leakage rates, system simplicity, reliability, and decompression protection. It ranks lower in fire dysbarism and atelectasis protection categories, they said.

OAR Report Questions Astronaut Adaptability

Two scientists under contract to the Air Force Office of Aerospace Research report that astronauts may not adapt as easily to space conditions as has been accepted. Dr. Sanford Freedman of Tufts University and Dr. Richard Held, Professor of Experimental Psychology at Massachusetts Institute of Technology, say that, in vision and hearing, if there is no correlated feedback, the accuracy of performance is degraded. In movement, if the body or its parts are prevented from making contact with external objects in a normal consistent manner, muscular contraction may be unrelated to certain aspects of bodily movement.

PROPULSION

Navy to Develop Army Hovering Rocket

A 16-man team at the Naval Ordnance Test Station, China Lake, Calif., will develop a Hovering Rocket System (HRS) for the Army's Ballistic Research Laboratories, according to NOTS. Designed for use in upper atmosphere research, HRS will use a two-stage, 27-ft.-long vehicle that will place a 700-lb. payload at an altitude between 65,600 and 164,000 ft. The second stage will be capable of stabilized hovering for 30 to 120 sec. in the upper atmosphere or near Earth space. The second stage, or hovering platform, measuring 19 ft. long and 3 ft. in diameter, will hold the guidance package. Present plans will utilize the second stage of the Army's *Pershing* missile as the HRS first, or booster stage.

MATERIALS

Shell Structures Studied by Martin

Martin-Denver engineers will investigate a theory that the most minute initial imperfections in lightweight, high strength metal shell structures affect shell behavior under pressure. Sponsored by the Air Force's Office of Scientific Research, the study will make use of a digital computer program written to solve the finite-deflection equations for shells of revolution under axisymmetric loads. The test models involved will be equivalent to the tank domes used in the *Titan I*, *Titan II*, and *Titan III*.

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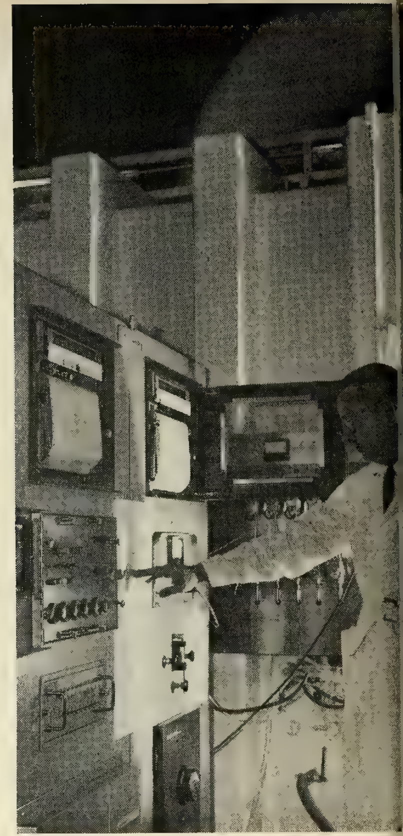


NASA, Boeing Resuming Life-Support Tests

More experiments encouraged by results of aborted attempt last summer; outlook for success improved

by Heather M. David

THE NATIONAL Aeronautics and Space Administration and the Boeing Co. in about two months will attempt to re-start a 30-day life-support experiment that was aborted after five days last July.

Although the experiment had an unfortunate and premature ending last summer, NASA's Office of Advanced Research and Technology reports that it learned perhaps more from it than from any other test in this field.

The five-man simulated space enviroment marked the first time chemical, physico-chemical and biological subsystems were integrated into a manned, regenerative operating life-support system. Almost all systems were boilerplate space cabin models.

According to NASA's Dr. Michael Del Duca, the trouble was caused by interaction between normally non-toxic materials. The run was shut down after all subjects developed extreme nausea and lost all interest in food.

Subjects also complained of an itchy feeling in the eyes, headaches, soreness and bleeding from the gums, welts on the mouth and lips, and one case of intense pain in the teeth of the upper jaw. At least one subject began perspiring, emitting a sweet pungent odor —the same found in the chamber during the run.

- **Changes made**—NASA and Boeing have spent the last six months examining materials and interactions to determine what went wrong. Careful bacteriological studies have been conducted on all samples taken during the test.

A number of minor modifications have been made, although the basic systems remain the same. They are:

Chemical—Sodium superoxide is used to adsorb carbon dioxide and other contaminants and to regenerate oxygen. Re-engineering included a look at canister design, size of crystals, compacting and resistance and possible contamination, in order to insure reliability of the system.

Bottled nitrogen is used to maintain a 21/79 mixture of gases at sea-level pressure.

Biological—An "activated sludge system," which consists of a bacterial suspension that feeds on waste materials from the crew and on food wastes. The processed material is then moved into a holding tank. This system has undergone modification to insure proper circulation of oxygen. Other minor mechanical fixes were made in the system.

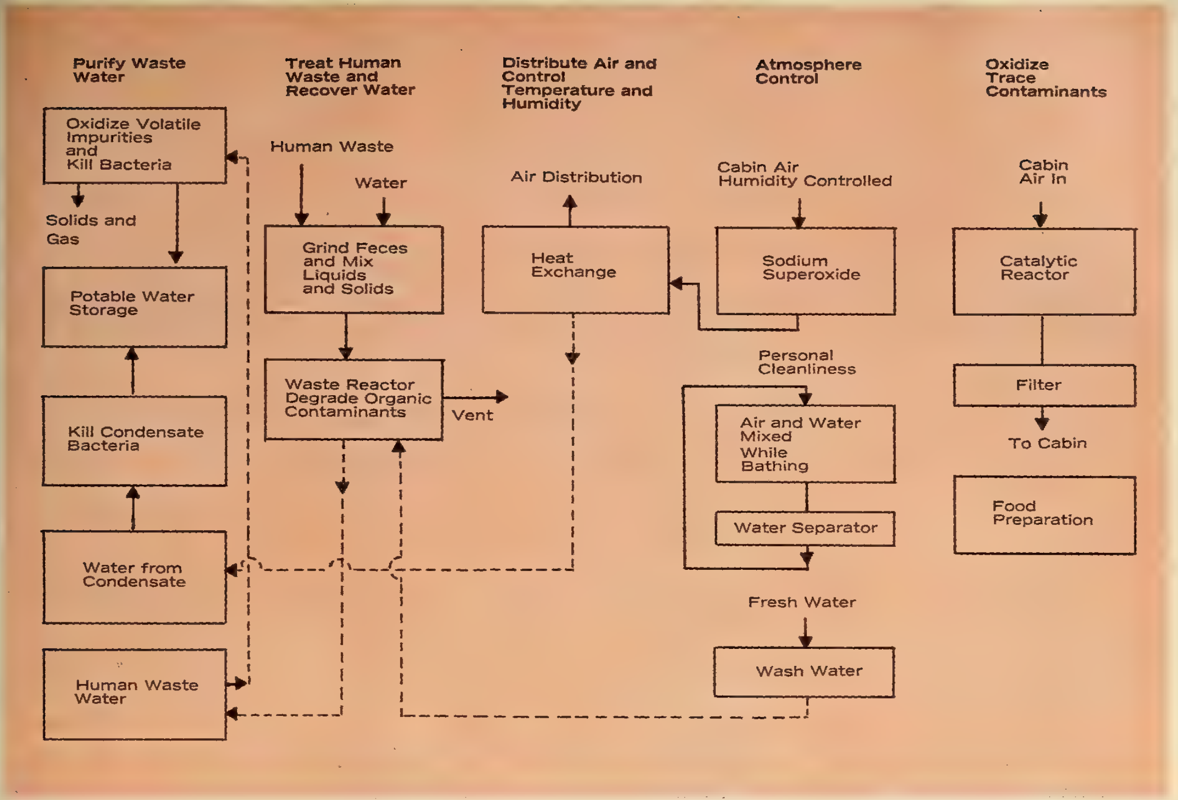
Physical—Because of the weightlessness requirement, a rather sophisticated centrifugal system for separating gases, solids and liquids in the holding tank had to be developed.

Water is purified by vapor distillation over a platinum aluminum catalyst, and recondensation. Gases in the effluent are channeled into a Hopcalite burner to remove contaminants and odors, and remaining solids are rechanneled into the bacterial tanks.

For the ground experiment, the crew is provided with a two-gallon, recirculating shower system. Soap and dirt are removed by an activated charcoal filter, and an ionic resin cell is used to neutralize hardness. Some other means, probably sponges, would be used in space, NASA said.

- **Noise problem**—The experimenters are now fitting components back into the chambers and carefully testing each. A number of short manned and unmanned checks will be made during the next month, until NASA is confident all the kinks have been worked out.

According to NASA's Layton Ingelfinger, there is some concern about noise levels in the chambers since in an effort to remove possibly contaminating organic materials, more metal surfaces were exposed. Engineers are now checking this area so that the level does not become irritating when the chamber is closed.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Distribute Air and Control Temperature and Humidity
Atmosphere Control
Oxidize Trace Contaminants
Oxidize Volatile Impurities and Kill Bacteria
Human Waste
Water
Air Distribution
Cabin Air Humidity Controlled
Cabin Air In
Solids and Gas
Grind Feces and Mix Liquids and Solids
Heat Exchange
Sodium Superoxide
Catalytic Reactor
Potable Water Storage
Waste Reactor Degrade Organic Contaminants
Vent
Personal Cleanliness
Filter
Kill Condensate Bacteria
Air and Water Mixed While Bathing
To Cabin
Food Preparation
Water Separator
Water from Condensate
Fresh Water
Human Waste Water
Wash Water

LEFT: Boeing technician monitoring Life-Support experiment console. ABOVE: Diagram of NASA/Boeing 30- to 60-day life support system units.

- **Significance**—What makes the test so important to NASA is that it is the first time a biological system has been operated with other systems and with a man. "This gives us the first step in looking at the problems of biological systems," Ingelfinger told MISSILES AND ROCKETS.

Ultimately, a food cycle could be attached by using the solid waste processed by the waste reactor for growing edible plants. In the present system, this is fed back into the reactor.

NASA points out that this combination of subsystems is not necessarily the latest word in a complete life-support system. Rather, its was chosen to study this very problem of interfaces that caused so much trouble.

If the 30-day test is sucessful. the space agency may decide to increase the run to 60 or even 90 days, or it may turn to optimizing the system by substituting more efficient subsystems. The Office of Manned Space Flight also is partially sponsoring the experiment.

- **Schedule**—If all goes well, the five men will remain in the 2,300-cu.-ft. chamber for a month, performing simulated space tasks. The cabin is equipped with bunks, a recreation area, eating area and bath.

One main console serves as control center for the capsule and has all subsystem information. The subsystems are completely operated by the crew, who are provided with operating manuals and instructions from the ground through closed-circuit TV.

Food is freeze-dried and prepared in a small galley, with 90° and 160° F water available. In addition, the crew has a small cooling ring for storage of prepared foods and beverages at 35° to 450° F.

Tasks performed by the crew include tracking, navigation, guidance, data gathering and mathematics. In addition, visual and auditory tasks and other psychological tasks will be used to check crew performance.

Much the same monitoring equipment used in the first test will be used. Dr. Del Duca said that the equipment did tell the experimenters that trouble was developing in the first run, and that "probably no test has been better monitored than this one."

Monitoring included physiological, psychological, bacteriological, gas sampling, nutritional, and chemical analyses. Naval Research Laboratories, Army's Ft. Belvoir, the University of Washington, Galbraith Labs, Beckman Instruments and three Boeing laboratories participated in analytical studies of the gaseous environment. Bacteriological studies were done at Boeing.

- **What may have gone wrong**—Although NASA feels it is not ready to claim it can pinpoint the trouble areas until it is sure the test will now be successful, Boeing's Dr. R. H. Lowry, chief of bioastronautics, mentioned these possibilities in an earlier report:

—hydrogen developed in the superoxide containers as the chemical interacted with the aluminum honeycomb canister material.

—ammonia in the waste reactor passed across the Hopcalite filter at 350° F and was partially oxidized into nitrogen dioxide. This gas also developed in the water purification system as it passed over the platinum catalyst at 1,100° F.

—polyvinyl sleeving covering electrical cables may have emitted tricresyl phosphate.

—neoprene rubber tubing, when carrying heated gases, began emitting the sickly sweet odor.

Re-engineering has eliminated these areas, Dr. Lowry said. But as Dr. Del Duca pointed out: "The integration parameters don't lend themselves to analysis. We really have to make the run to find out." ■

EBW Field Needs Systems Approach

Complex electro-explosive interface is core of problems hobbling successful application in missile/space areas

by John F. Judge

THE MAIN CAUSE of the troubles plaguing exploding bridgewire ordnance in missile and space programs is the failure of the designers to consider ordnance as a system.

Weldon Bankston of Hi-Shear Corp., Torrance, Calif. says that with the advent of exploding bridgewire (EBW) ordnance, companies in aerospace and military programs were quick to incorporate the devices in their ordnance system designs.

Most of the projects ran into difficulties, since the majority of EBW ordnance systems were approached with a split responsibility.

- **Schizoid approach**—An ordnance manufacturer was given the task of fabricating an EBW ordnance device and an electronics component manufacturer the task of producing the firing unit or power supply.

At first glance, says Bankston, this would have appeared to be a logical approach to the problem—but the design interface here becomes extremely critical. Definitions of the interface, as well as its method of measurement, must be determined and rigidly monitored.

Not all wire explosions are the same. The explosive output of a wire is affected by its material type, diameter, length, current density and rate of application of the electrical energy. These requirements, coupled with the ordnance material requirements of proper crystal size, density and header geometry, illustrate the complexity of the interface that must be determined and controlled.

Since on one side of the interface—the wire—there is a complex electrical phenomenon and on the other side a chemically explosive reaction, a true and critical electro-explosive interface exists, says Bankston.

- **Early systems mismatched**—The result of initial attempts of most pioneering companies in EBW was a mismatched system that lacked reliability. In most cases, it was a direct result of inadequate interface definition and control.

Bankston points to the analogous situation in designing an efficient transmitter. Transmission line is designed by one firm, efficient antenna by another, with all unknowns being centered in the matching device—which was not completely defined. The matching device in the EBW ordnance system, is the exploding wire/ordnance interface.

Bankston says this is also the point at which the most variables occur. For this reason, most of the interface values must be determined empirically, then carefully controlled.

A complete EBW ordnance system as produced by the Hi-Shear Corp. consists of an EBW ordnance device, transmission line, and initiator command module (ICM).

- **Safety considerations**—Although EBW ordnance cannot normally be actuated by power sources used for conventional ordnance, ac line voltages (110, 220v ac) can initiate it by brute force if inadvertently applied across the device.

To counteract this eventuality, and to take advantage of the high-voltage nature of EBW, a spark gap is placed in series with the wire in the device. The breakdown voltage of the gap is generally set between 500 and 1,000v, thereby preventing anything except a high-voltage, high-current pulse from

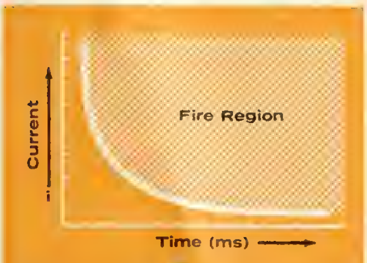

Figure 1 CURRENT – TIME CURVE FOR ORDNANCE DEVICES

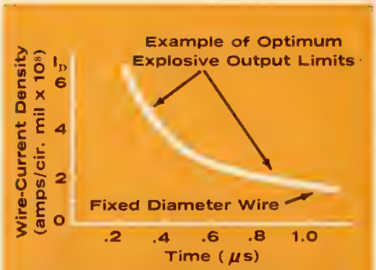

Figure 2 CURRENT DENSITY VS FIRING TIME FOR AN EXPLODING WIRE

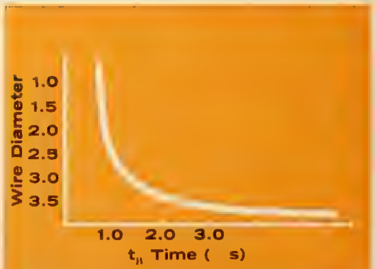

Figure 3 CURVE OF WIRE FIRING TIMES WITH CURRENT SOURCE CONSTANT

jumping the gap and exploding the wire.

The Hi-Shear Corp. has established the interface requirements for its EBW ordnance devices by determining the quantity of electrical energy required to initiate each of them, and the rate of application at the interface.

These requirements are said to be satisfied by Hi-Shear's EBW initiator command modules or their equivalents. The ability of other EBW firing units to reliably initiate Hi-Shear EBW ordnance can be determined by use of the Hi-Shear TL-2 test load, which duplicates the dynamic resistance of the ordnance.

Several types of ordnance material, some of proprietary nature, have been successfully and reliably incorporated in the Hi-Shear ordnance systems. Many secondary high explosives—among them PETN—have been detonated by Hi-Shear exploding wire systems. To date, only PETN is being used in the Hi-Shear PE500 detonators. Other high-explosive detonator types are being tested.

Primary high-explosive sensitivity hazards are not present in Hi-Shear EBW ordnance systems since no primary high explosives are employed. Powder crystal sizes, packing density and header geometry are proprietary, but meet conventional ordnance requirements.

- **Little theory**—Although a great deal of the information concerning EBW systems is determined empirically, says Bankston, some analytical considerations can be made. To elaborate on the five previously outlined items that affect the functioning of an EBW system, the best starting point is the wire itself.

Basically, wire materials fall into two categories: those of a low boiling point, low heat of vaporization, and those of a high boiling point, high heat of vaporization.

Evaluations made with wires, without ordnance, indicate considerably more energy can be placed in the low-boiling-point materials before the physical explosion of the wire than can be placed in the high-boiling-point materials. This results in "superheating" of the wire materials and appears to provide greater velocity to the shock front produced from the wire explosion. It is also hypothesized to be the cause of the "anomalous resistance" of exploding wires, says Bankston.

The energy placed in the wire before detonation is represented by

$$U = \int_0^{t_b} ivdt$$

in which *i* is the current in the wire, *v* the voltage across it during the explosion period, and *tb* the time of wire burst. However, one of the most important equations that can be used in practical systems applications is the "action integral" represented by

$$I(t) = \int i^2 dt = \int idq.$$

Many elaborate test and instrumentation arrangements have been devised to monitor the current in the wires during the explosion, as well as to measure voltage across them. Energy determinations made in this fashion lend themselves to laboratory conditions but lack the consistency obtained with the "action integral", says Bankston.

For this reason, the current-time dynamics of the Hi-Shear EBW ordnance systems are used to evaluate system condition and adequacy. Bankston says measurement of current during the explosion provides accurate insight into the operation of the system.

- **Wire diameter**—Conventional low-voltage ordnance devices fire according to a current versus time curve (Fig. 1). The curve merely indicates that for a given device, a certain level of current applied for a finite period of time results in a "fire." Lower currents must be applied for longer times and higher currents for shorter times to fire the same device.

The "no-fire" levels are represented by the areas in which the graph becomes asymtotic, indicating either a high-current value applied for an extremely short time or a very low current applied for a long time, both insufficient to initiate the device.

Exploding wire ordnance depends on much the same type curve, except *i*, or current scale, is replaced by I_D, or "current density," in the wire, with each wire diameter of the same material requiring the same current density for a similar reaction (Fig. 2). Holding the current source constant and varying the wire diameter produces the same type curve (Fig. 3), demonstrating that increasing the current density reduces the reaction time of the wire.

Care must be taken, notes Bankston, when using this curve for ordnance application—because all wires that "snap" do not explode.

- **Explosions vs. snaps**—There is a definite amount of current that must be delivered to all wires within a finite time to produce an "explosion," as opposed to merely a snap. The difference cannot be ascertained audibly, says Bankston, and in system applications must be determined by precise measurements. Tests designed to measure the shock waves produced by the wires can, and do, indicate when sufficient current density is reached in the wire.

Energy level determinations made at Hi-Shear on exploding wires have resulted in the use of two wire materials in the various EBW ordnance devices. One is a high-boiling-point alloy, the other a low-boiling-point alloy for heat and shock wave generation, respectively.

In the design of an EBW system, Bankston maintains that detailed consideration must be given to the dynamic and static voltage breakdown characteristics of any voltage-blocking device placed in series with the wires of the EBW ordnance device.

Since there are a variety of items that can be used (spark gaps, diodes, compounds, etc.) and each has special breakdown characteristics, Bankston says that among the design considera-

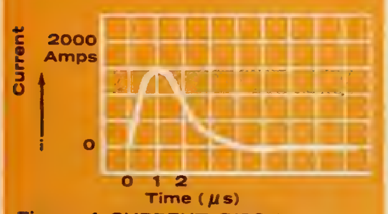

Figure 4 CURRENT DISCHARGE THROUGH EBW TEST LOAD

An example of the current pulse used to explode the wires of EBW devices is shown in Fig. 4. This oscilloscope photo was taken across a non-inductive resistive load that simulates the dynamic resistance of the wire during the explosion. The resistance value was laboriously determined from energy measurements on the wire during the explosion. When compared with Fig. 5, it can be seen that the slope of the current di/dt in the resistive load duplicates the slope of the current in the wire up to the point of wire burst t_b.

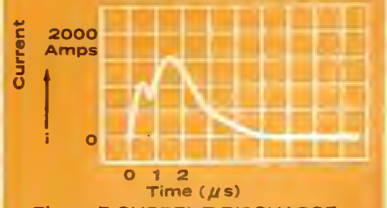

Figure 5 CURRENT DISCHARGE THROUGH EBW

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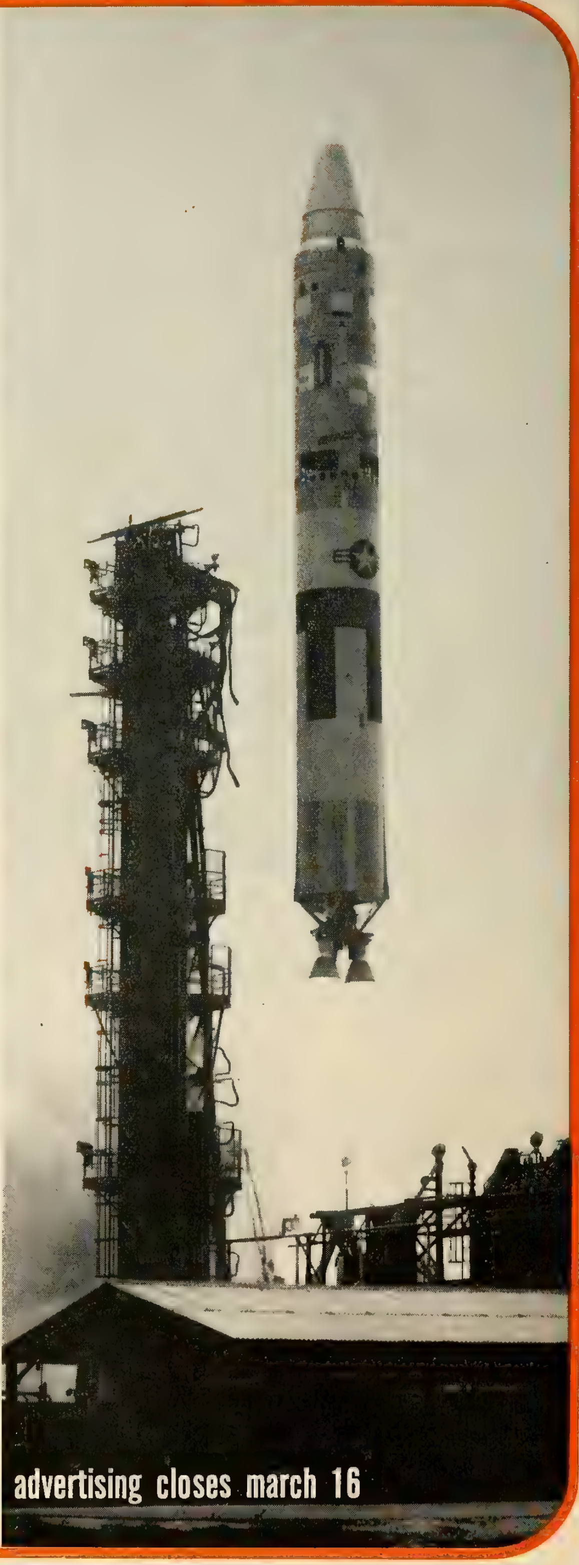

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tions that must be made upon selecting any such device are the following: repeatibility of breakdown voltage; low voltage drop; low capacitance; invulnerability to high-voltage spikes, and most important, capability of being tested within the ordnance device.

Assuming that these considerations have been made and met, the next requirements fall upon the electrical interface of the firing unit, transmission line, and the ordnance device. Since several thousand volts are used in this application, Bankston says that good standard engineering practices must be observed in designing the interface—particularly if it is to be used at altitude.

Coaxial connectors lend themselves quite readily to this application, since they may be easily matched to low-loss coaxial transmission lines, and the pin-to-case spacing of the ordnance device provides a long arc path in a minimum area. For isolated grounds, it becomes necessary to use two pin devices.

- **The transmission line**—The next consideration involves the transmission line. Assuming that the current density required by the wire has been established, that tests are completed, the current-density curve plotted, the minimum rate of current application to the wire, and the maximum time allowed to deliver it have been defined, the optimum operating range is then defined by dI/dt, or the slope of the current density curve with limits on time so that:

$$dI/dt \Big]_{t_1}^{t_2}$$

where *I* is the current density in the wire and t_1, t_2 are the minimum and maximum time limits, respectively.

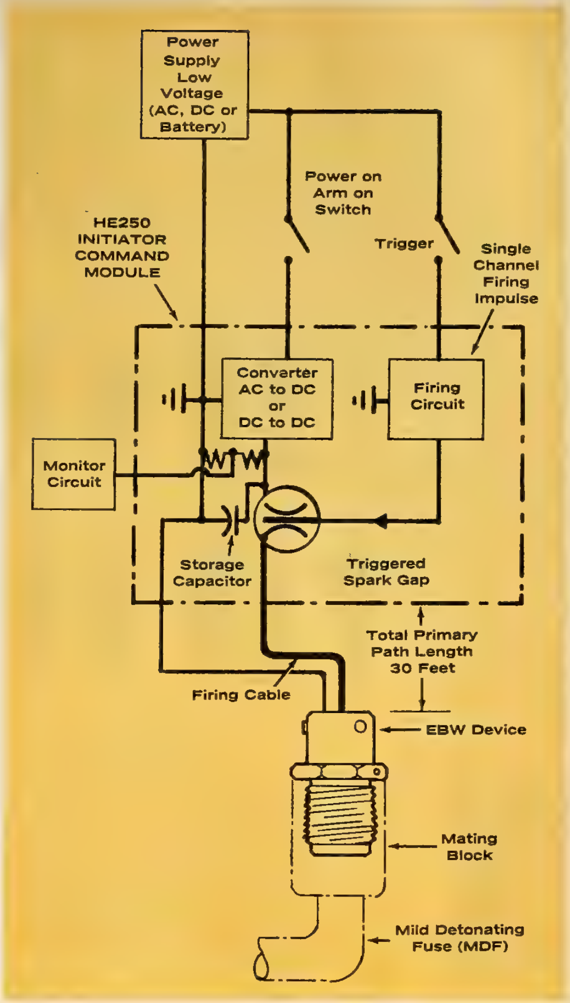
The significance of this value, when related to the transmission line, is that it establishes the maximum inductance permitted in the line (i.e., maximum line length) while remaining on the firing curve. It has been noticed in some applications that a certain amount of inductance in the circuit is desirable.

When evaluating the current-shaping effects of line inductances, Bankston says the oscilloscope photographs across the pre-calibrated dummy load are invaluable. The dummy load, used in conjunction with established test values, allows accurate determinations to be made of any power source's capability to initiate the EBW ordnance device for which it has been calibrated.

Some transmission lines, such as ribbon cable, though of low impedance, have the disadvantage of high capacitance. The capacitance of the line shunts a portion of the current pulse. For this reason low capacitance is desirable in the transmission line.

A low-resistance line is desirable to eliminate the large voltage drops associated with the extremely high currents involved. With a total system series resistance of 0.10 ohms, the 3,000-ampere current pulse suffers a voltage drop of 300v, says Bankston. Thus, if an EBW system's electrical requirements are not properly defined and calibrated, the accumulated effects of uncontrolled circuit characteristics can greatly reduce the desired reliability.

- **Power source**—The electrical source must be capable of delivering the electrical power required to the wire at a rate that places it within its explosive curve while overcoming all circuit losses. The source or firing unit that produces the largest current pulse with the sharpest rise time can effectively be used with the longest (most inductive, resistive and capacitive) firing lines, all other things being equal.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Firing Cable
EBW Device
Mating Block
Mild Detonating Fuse (MDF)

Typical Hi-Shear Corp. EBW system.

Firing units for EBW devices are usually solid-state in design and are armed by the application of low-voltage batteries or ac line voltages. The input voltages are either "chopped" and/or amplified, rectified and stored on a capacitor. The stored voltage is generally greater than 2,000v.

A high-voltage switch is then employed to transfer the stored energy of the capacitor to the transmission line. Again, the firing unit's discharge circuit plays an important part, says Bankston. The "turn on" time of the switching device must be taken into account and pre-conductance or "sputtering" cannot be tolerated.

Other considerations, dependent primarily on the intended environment of the unit, include volume, tightness, weight, charge time and power source. In general, the electrical input characteristics are much more easily resolved than the discharge characteristics.

- **RF hazards**—Bankston says that EBW ordnance has been shown to be relatively insentisitve to initiation by electromagnetic radiation at all frequencies. Most EBW ordnance devices are evaluated at 10 to 100 times the RF power levels to which low-voltage ordnance is tested.

When discussing RF hazards with respect to EBW systems, however, the firing unit sentitivity must also be considered. In general, it is easier—since there is more working volume—to decrease the sentitivity of the firing units to a failure level much greater than that of conventional ordnance used as a reference. Several methods of accomplishing this are used and all methods generally employ some form of voltage blocking, rectifying and filtering. ■

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missiles and rockets
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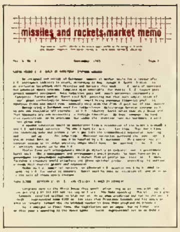
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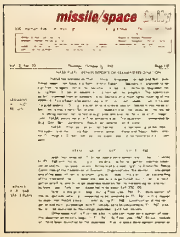
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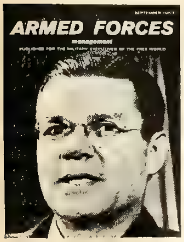
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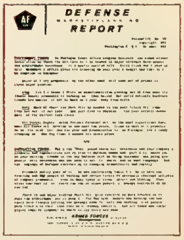
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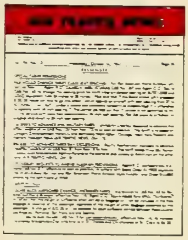

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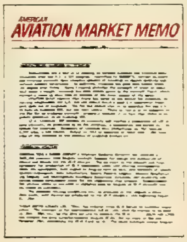

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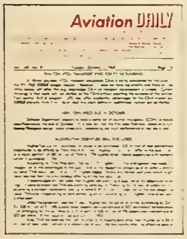

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Relay II Performance Is 'Beautiful' In Initial Test Transmission

RCA-built satellite passes early transmission tests; longer operating life and improved work expected; Delta's 22nd success

by Chris Butler

CAPE KENNEDY—The *Relay II* communications satellite was launched Jan. 21 here into an orbit that almost exactly matched pre-launch predictions.

Trackers fixed the orbit path the next day at 4,606.27 mi. apogee, and 1,298.1 mi. perigee, with a period of 194.73 minutes and inclination of 46.312 degrees.

The 183.6-lb. spacecraft, built by Radio Corp. of America, successfully transmitted television test patterns at the end of its first orbit and performed successfully when tested on subsequent orbits.

On the fourth orbit, Jan. 22, engineers in Nutley, N.J., and West Germany conversed via the satellite.

A NASA spokesman said the spacecraft was "working beautifully. We're very pleased with it."

Last-minute details of arrangements postponed the *Relay's* first planned live television demonstration on the 22nd, when President Johnson was to have greeted Japanese viewers.

Eventually, ground stations in seven nations on four continents are expected to conduct TV, radio, teletype and telephone experiments utilizing *Relay II*. The satellite carries new electronic systems which are expected to enable it to operate for several years, withstanding effects of radiation and other space hazards.

• **Changes made**—*Relay II* is very similar to *Relay I*, launched from Cape Kennedy Dec. 13, 1962, which proved a tremendous success in intercontinental communication transmission.

Principal differences between the satellites are *Relay II's* more efficient orbit, longer expected operating life and several internal changes designed to improve operation over the earlier design.

The planned orbit—so nearly matched in the launching—called for an apogee of about 4,600 mi., similar to that achieved by *Relay I*, but a perigee of 1,325 mi., considerably higher than *Relay I's* 818 mi.

The less elliptical orbit is designed to lengthen periods of mutual visibility between ground stations, permitting up to 70 minutes of continuous transmission between U.S. and European stations and 40 minutes between U.S. and Japanese stations.

The use of N-on-P solar cells is expected to extend the life of *Relay II* to as much as 10 years, but spokesmen from Goddard Space Flight Center and Radio Corp. of America stressed that such a life span also would depend on the lifetime of other components of the spacecraft. Robert H. Pickard, spacecraft manager for GSFC, said P-on-N cells on *Relay I* have degraded from radiation to only about 40% of the original output.

Included among *Relay II's* 8,215 solar cells is a panel with 30 selected cells to study damage from radiation. The test cells include a number of N-on-P and P-on-N cells to provide a comparison of deterioriation, and 10 gallium arsenide cells. The latter include two unshielded cells and two each with shielding of two, six, 12, 30 and 60 mils thickness.

The solar cell panels on the octagonal satellite will supply power to three nickel-cadmium storage batteries containing 21 cells each to provide sufficient power for the spacecraft's average operational requirement of 45 watts.

Designers of *Relay II* substituted an unpressurized traveling wave tube for one of the two pressurized travèling wave tubes on *Relay I*, in order to permit comparison of performance while the spacecraft is in orbit.

Other changes included elimination of the one-year timer, improvement of command circuitry to reject spurious commands generated by stray radiation, installation of improved transistors in the high-power voltage regulator, addition of magnetic latching relays to provide a redundant method of turning off the wideband power supply, and installation of five sensors near voltage regulator transistors to determine when temperatures become critical.

Like *Relay I*, the new satellite carries redundant transponders to assure that communications tests can be run. It also has the same complex telemetry and command system to operate and report on the satellite's condition and performance.

• **22 for Delta**—The satellite launch by the three-stage *Delta* was described as "routine." A yaw movement was programmed into the first-stage flight for the first time. Yaw movements also were programmed into the second- and third-stage flights.

The satellite, spin-stabilized at 150 rpm, was injected into orbit over the Atlantic Ocean in the 22nd consecutive success for the Douglas-built *Thor-Delta* booster.

The next assignment for *Delta*—expected before the end of March—will be the launch of the *S-66* Polar Ionosphere Beacon satellite, which originally was intended for launch on the West Coast. It will be the first time a near-polar orbit has been attempted from Cape Kennedy.

The *Delta* will be launched southeastward from Cape Kennedy and execute a difficult dogleg turn to the south to place the satellite in an orbit with a 70-degree inclination to the equator. ■

Mergers and Acquisitions

National Measurements Laboratory has acquired Metrolonics Associates, an independent standardization laboratory located in Burbank, Calif. Metrolonics will be operated as a division of NML and will remain in Burbank. . . . *Kawecki Chemical Co., Boyertown, Pa., has acquired Penn Rare Metals, Inc., of Revere, Pa. Kawecki, which has held a 50% interest in Penn and acted as its exclusive sales agent since 1960, will assume direct management of Penn and operate it is a wholly owned subsidiary. Penn produces germanium, cesium, rubidium, tellurium and other high purity metals and compounds. Kawecki's present major products are columbium, tantalum, selenium and aluminum-base master alloys.*

New Firms and Divisions

Martin Marietta Corp. and Thompson Ramo Wooldridge, Inc., have jointly established The Bunker-Ramo Corp. in Canoga Park, Calif., to continue and expand work both companies have been pursuing in the design and installation of electronic control systems for government and industry. The new corporation has acquired the products, resources, facilities and personnel of two existing divisions of the parent firms. It will manufacture precision electronic equipment, but primary purpose is design, engineering and installation of on-line control systems requiring many types of electronic, mechanical and computer devices. Martin Marietta will own 90% of the new corporation. TRW will own 10% initially, with an option to double its holdings. TRW also will receive cash approximating its investment in the computer operation. . . . *Avco Corp.'s Research and Advanced Development Div. has established a new organization to direct and conduct space systems work. The new organization is to conduct the division's present space programs and space-oriented research and development and will direct research and facilities planning necessary for Avco participation in future space systems. Objective is to provide centralized management for an integrated approach to research problems and systems development problems common to space programs.* . . . Lockheed Missiles & Space Co., Sunnyvale, Calif., has established a new subdivision within its Space Programs Div. The new organization, Large Space Vehicles Programs, succeeds Nuclear Space Programs, which conducted the RIFT project. Large Space Vehicles will conduct supporting research and technology related to large space vehicles of the *Saturn* class. . . . *Anken Chemical & Film Corp., Newton, N.J., manufacturer of photocopy equipment and supplies, has formed an Aerospace Div., with headquarters in Los Angeles, to specialize in development, sales and service of equipment geared to the specific needs of the missile/space and aviation industries. The new division will represent AC&F in manufacturing, research and development of applications for photocopy equipment and sensitized materials in the missile/space industry. The division will also administer unified sales, training and service policies to the industry throughout the country.*

A.I.P. to Offer Placement Service

The American Institute of Physics will hold a placement service register in conjunction with a joint meeting with the American Association of Physics Teachers at the Statler-Hilton Hotel in New York City Jan. 22-25. The register offers physicists who have given their qualifications to the placement service and notified it of their intention to attend the joint meeting the opportunity of meeting with representatives of industrial, academic and governmental research institutions to discuss employment.

International

Houston Instrument Corp., Houston, has completed a cross-licensing agreement with Advance Components, Ltd., of Essex, England. The agreement is effectively a merger, except for an exchange of stock. Initially, Advance exercised its option to manufacture and market Houston's X-Y and T-Y recorder line. HI elected to produce Advance's line of signal generators, a millivoltmeter and its double pulse generator. Under the agreement, HI will limit its future marketing operations on all licensed products to the Americas and surrender most of its other foreign sales to the English company. The move is said to nearly double the R&D facilities of both firms.

Industry Facilities

Electra Manufacturing Co., Independence, Kan., has announced plans for establishment of a central research laboratory in southern California. The plant will be responsible for all technical activities relating to new products and processes. . . . *Sylvania Electric Products, Inc., New York, has erected a 15,000-sq.-ft. structure at its Mountain View, Calif., plant. The inflated nylon structure will house expanded research and development of rigid foam antennas and devices for the company's Electronic Systems Div.* . . . Hoffman Electronics Corp., formerly of Los Angeles, has moved its facilities to El Monte, Calif. . . . *Universal-Cyclops Steel Corp., Bridgeville, Pa., has begun operation of two new vacuum arc remelting furnaces at its Titusville, Pa., plant.*

Company Representatives

Royco Instruments, Inc., Menlo Park, Calif., has named two new distributors. Fisher Scientific Co., Pittsburgh, Pa., will cover areas east of the Rocky Mountains, including Canada. Van Waters & Rogers, Inc., Brisbane, Calif., will handle areas west of the Rockies, including Alaska and Hawaii. Royco manufactures test and measuring instruments for the electronics and missile/space industries.

contracts and procurements

AWARDS

AIR FORCE

$9,500,000—**Page Communications Engineers, Inc.,** Washington, D.C., for a Far East communications system, including installation, production and checkout.

$6,700,000—**Boeing Co.,** Seattle, for continued production and installation of *Minuteman* ICBMs at Grand Forks, AFB, N.D.

$2,500,000—**North American Aviation, Inc., Rocketdyne Div.,** Canoga Park, Calif., for continued production of engines for *Atlas* boosters.

$1,700,000—**General Dynamics Corp.,** New York City, for launch support services for the Atlantic Missile Range.

$1,400,000—**Trustees of Columbia University,** New York City, for continuation of Project Defender studies of ARPA origin.

$1,000,000—**Lockheed Missiles and Space Co.,** Sunnyvale, Calif., for work on a classified contract.

$300,000—**Allis-Chalmers,** Milwaukee, Wis., for production of three self-contained fuel cell systems for possible use as power sources in future space projects.

$179,343—**California Institute of Technology,** Pasadena, for research on stellar compositions and processes.

$117,440—**Boeing Co.,** Seattle, for engineering services applicable to *Minuteman* ICBMs.

$71,971—**Atlantic Research Corp.,** Alexandria, Va., for continued research on deflagration of high-energy solid oxidizers.

$64,501—**Bendix Corp., Eclipse-Pioneer Div.,** Teterboro, N.J., for an interferometric shaft encoder.

$38,199—**Radiation Applications, Inc.,** Long Island City, N.Y., for radiation-initiated solid rocket propellant decomposition.

$33,250—**Essex Cryogenics, Inc.,** St. Louis, Mo., for a reliability LOX converter.

$28,900—**California Institute of Technology,** Pasadena, for research in laser electromagnetics.

Ling-Temco-Vought, Dallas, for continuation of advanced development studies on the Low Altitude Supersonic Vehicle (LASV) program (undisclosed amount).

ARMY

$63,366,378—**Morrison-Knudson, Perini Corp., and Paul Hardeman, Inc.,** South Gate, Calif., for general and mechanical construction work to complete the John F. Kennedy Space Center's vertical assembly building.

$15,599,775—**Boeing Co.,** Seattle, for development of a new high-acceleration experimental missile booster.

$9,700,000—**Hughes Aircraft Co.,** Culver City, Calif., for satellite communications system terminals.

$5,000,000—**Burroughs Corp.,** Detroit, Mich., for work on a classified electronics program.

$4,000,000—**Philco Corp.,** Philadelphia, Pa., for work on a classified electronics program.

$1,200,000—**Western Electric Corp.,** New York City, for work supporting Project Sleighride, an effort aimed at investigating vulnerability of missiles as they re-enter the atmosphere.

$124,000—**Regents of the University of Michigan,** Ann Arbor, Mich., for a one-year study and research and development effort for target signature work.

$107,701—**Martin Marietta Corp., Orlando Div.,** Fla., for technical non-personnel services in the field for the *Nike-Hercules* Missile Master system.

$26,656—**American Bosch Arma Corp.,** Springfield, Mass., for 3012 nozzle assemblies for rockets.

NAVY

$54,600,000—**Lockheed Missiles and Space Co.,** Sunnyvale, Calif., for continued research and development on the *Polaris A3* missile.

$11,900,000—**General Electric Co.,** Pittsfield, Mass., for manufacture of advanced *Polaris* guidance system assemblies.

$5,700,000—**Lockheed Missiles and Space Co.,** Sunnyvale, Calif., for *Polaris* missile test equipment.

$5,300,000—**General Instrument Corp.,** Hicksville, N.Y., for production of countermeasure sets to be used on Navy ships.

$3,600,000—**Northrop Corp.,** Norwood, Mass., for manufacture of *Polaris* missile system gyros.

$1,800,000—**North American Aviation, Inc., Rocketdyne Div.,** Canoga Park, Calif., for production of rocket motors for *Sparrow III* missiles.

United Aircraft Corp., Norden Div., Norwalk, Conn., for 615 shaft position encoders for use in the *Polaris* missile program.

NASA

$2,000,000—**Computer Applications, Inc.,** New York City, for provision of automatic data processing services, including the operation of a large computing installation for the Launch Operations Center near Cape Kennedy.

$1,000,000—**Vector Manufacturing Co., Inc.,** College Park, Md., for telemetry equipment.

$977,100—**Her Majesty's Postmaster General in the United Kingdom of Great Britain and Northern Ireland,** for communications services.

$450,000—**Bendix Corp., Bendix-Pacific Div.,** North Hollywood, Calif., for telemetry components for the *Centaur* space vehicle (several contracts).

$215,000—**Technical Materials Corp.,** Mamaroneck, N.Y., for high frequency diversity radio receivers and spare parts.

$185,800—**American Machine and Foundry Co.,** Santa Barbara, Calif., for a deceleration mechanism for a drop tower.

$140,801—**Space Craft, Inc.,** Huntsville, Ala., for fabrication of welded circuit modules.

$102,875—**Textron Electronics, Inc.,** Sylmar, Calif., for solar cell panels.

$97,778—**Boyd & Goforth, Inc.,** Charlotte, N.C., for construction of additional facilities at the Rosman, N.C., site of NASA's wideband data acquisition facility.

$97,000—**Rocket Research Corp.,** Seattle, for the development of a solid propellant rocket for the control of satellites and space vehicles.

$48,000—**Space General Corp.,** El Monte, Calif., for evaluation and review services covering the *Surveyor* program.

$30,590—**Motorola, Inc., Western Div.,** Scottsdale, Ariz., for command receivers.

INDUSTRY

$535,000—**Universal Match Co., Unidynamics Div.,** Phoenix, from the **Boeing Co. Aero-Space Div.,** for stage separation and skirt removal kits for *Minuteman* ICBMs.

$250,000—**PurOlator Products, Inc., Mark Couplings Div.,** Los Angeles, from **North American Aviation's Space and Information Systems Div.,** for the development and production of helium disconnect couplings for the *Apollo* manned lunar landing program.

$175,000—**Rohr Corp.,** Riverside, Calif., from **Lockheed Propulsion Co.,** for insulation of motor case segments to be used in a 156-inch diameter solid propellant rocket feasibility demonstration program.

Electro-Mechanical Research, Inc., Sarasota, Fla., from the **Jet Propulsion Laboratory,** for an investigation of video modulation techniques suited to the transmission of single-frame television pictures from an unmanned vehicle in deep space (undisclosed amount).

Swedlow, Inc., Los Angeles, from **North American Aviation's Rocketdyne Div.,** for motor case insulative liners for the *Sparrow III* air-to-air guided missile (undisclosed amount).

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Purchasing Dept. 311-4
Naval Supply Center
Oakland, Calif.

The Contracting Officer, Purchasing Dept., will negotiate a contract with Bendix Systems Div., Bendix Corp., Ann Arbor, Mich., for continuation of research work previously performed regarding effect of gamma rays on electronic circuitry. This notice is for record purposes only. Adequate plans, drawings or specs are not available. RFP-228-2196-64. RFP available at the Naval Supply Center, Oakland, Calif.

Advanced Studies Branch, SEKMA
Systems Engineering Group
Research & Technology Div.
Wright-Patterson AFB, Ohio

Negotiations to be conducted with Electro Optical Systems, Inc., 125 N. Vinedo Ave., Pasadena, Calif., for extension of Contract AF33/657/7940, inter-action between electric arcs and gas flows in the arc column region. Note: For information only. No RFP available. PR 192835-KMA.

Negotiations to be conducted with General Electric Co., 4966 Woodland Ave., Cleveland 4, Ohio, for extension of Contract AF-33/657-8206, research on electric arc cathode and adjoining transition regions. Note: For information only. No RFP available. PR 92833KMA.

Aerospace Medical Div.
Attn: AMKRB
Post Office Box 35448
Brooks AFB, Tex.

Negotiations will be conducted with the Hine Laboratories, 1099 Folsom St., San Francisco, for studies to assess the influence of variation in environmental temperature on the systematic effects of alcohol. For information only. RFP not available.

New Product of the Week:

Welding Positioner

A 50-lb. capacity welding positioner for use in inert gas atmosphere and vacuum welding chambers is being marketed by Aronson Machine Co., Inc.

The model B50P features a lubricated and sealed positioner mounted inside a chamber and an external electronic control panel for easy access. The unit provides 360-degree table rotation at 0.1 to 10 rpm, plus 360 degress of tilt with 45-degree index locking and 360-degree pedestal rotation.

Circle No. 151 on Subscriber Service Card

Midget Chopper

Cambridge Scientific Industries is marketing a midget electro-mechanical chopper, measuring 0.4 in. in diameter and weighing 12 grams.

The all-welded unit has a noise level of less than one microvolt RMS as measured into a 100-K-ohm load. It can withstand vibrations of 10 g's to 2,000 cps. The unit can be driven by almost all wave shapes; frequencies up to 1,000 cps are available. Operating life exceeds 2,000 hours.

Circle No. 152 on Subscriber Service Card

Digital Encoder

A 1,024-count one-brush absolute position digital encoder is being marketed by Perkin-Elmer Corp.

The Model 1/1024 utilizes a one-brush concept of obtaining absolute position information and provides low running and starting torques. The only moving members of the system are the brush and shaft.

A range of four-digit solid-state readouts provide decimal light readout 8421 BDC output, buffer storage, decimal printer output or any combination.

Circle No. 153 on Subscriber Service Card

L-Band Klystron

Electron Tube Div. of Litton Industries has developed a 5-megawatt, 300-kilowatt average L-band klystron.

The L-3401 is tunable from 1,254 to 1,386 megacycles with an RF duty cycle of 0.063 and a pulse length of 42 microseconds.

Typical operating parameters are a beam voltage of 135 kv, a beam current of 120 amperes, with an average beam power of approximately 1.3 megawatts. Gain is rated at 35 db.

Circle No. 154 on Subscriber Service Card

Digitizing Data System

A data system that automatically digitizes stereo photogrammetry information from X, Y, Z coordinates into computer language for further reduction has been manufactured jointly by the Kelsh Instrument Co., Inc., and Data Instruments Div., Telecomputing Corp.

The unit is basically a plotter equipped with magnetic reading heads, a digitized computer input converter and any of several output recording devices.

System specifications include a count rate of 0 to 50,000 per second, accuracy of ±one count, power requirements of 105 to 120v, 60 cps, 50 watts.

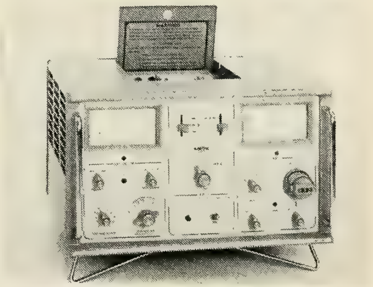
Circle No. 155 on Subscriber Service Card

Transistor Tester

Sierra Electronics-Philco Corp. has developed the Model 500A power transistor test set designed to measure the parameters of transistors and other semiconductor devices while operating at ambient to elevated temperatures.

Featuring a heat-sink that can be controlled for temperatures of ambient, 40°, 50°, 60°, 70° and 80°C, the unit can test PNP, NPN, medium- and high-power transistors, rectifiers, diodes, SCR's and zener diodes at voltage levels to 300v with peak currents to 50 amperes.

The instrument presents digital readout of transistor beta in 0 to 50 or 0 to 500 ranges, with an accuracy of 3% of the actual reading. A SCR gating circuit generates 20% duty cycle, high peak-power pulses. A transistor switch protects the instrument from shorted transistors.



Circle No. 156 on Subscriber Service Card

Temperature Chamber

Gruenberg Electric Co., Inc., is marketing a line of precision temperature chambers with control to 0.1°F in a range of —100° to 500°F.

Two models with working capacities of one and four cubic feet are liquid CO_2 cooled. The units feature high volume air flow, temperature rate control and hinged removable door. Automatic cycling is available.

Circle No. 157 on Subscriber Service Card

AC Stable Standard

Rotek Instrument Corp. is marketing the Model 715 ac stable standard, designed for use in gyro systems development and test.

The unit has an output voltage of 1 to 121v RMS and is available in decade selections and with continuous resolution. Stability is guaranteed to be 50 ppm per week; frequency range is 350 to 4,800 cps; distortion from 0 to full load will not exceed 0.03%.

The system features linear, transient-suppressed switching circuits; an output meter; 50% over ranging on voltage, and MIL-E-4158 specifications.

Circle No. 158 on Subscriber Service Card

A-D Converters

Systron-Donner Corp. is marketing the Models 1234 and 1234A analog-to-digital converters, designed for instantaneous response and 2-μsec. conversion.

With an input of ±10v full scale, Model 1234 samples at 300 per second to ±0.05% and Model 1234A at 30 per second to ±0.01%. The units feature in-line readout, stored BCD output and synchronization with external programmers.

Circle No. 159 on Subscriber Service Card

Remote Control System

A solid-state remote control system for VHF radio base station switching has been developed by Noller Control Systems, Inc.

The system provides remote control facilities with check-back from remote terminals for any VHF radio voice communication installation of up to nine remote stations per channel frequency. The dispatcher is provided with 10 individual and/or 10 common controls for each remote station. Operating speed is less than 200 ms for all functions.

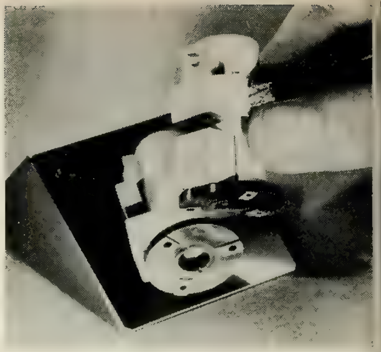
Control commands include station select, frequency select, individual and common receiver mute and release, open and close V.F. line on far side of selected remote, all call, system reset and push-to-talk.

Circle No. 160 on Subscriber Service Card

Optical Angle Sensor

Perkin-Elmer Corp. is marketing a subminiature two-axis optical pickoff for precision angular alignment. Resolution exceeds 0.1 second of arc.

The Model 1C is especially suited to sensing attitude of gyro rotors since the only contact with the monitored element is with a beam of collimated light. The unit can generate a signal to hold components in a fixed relationship or used as a follower for tracking angular movements. Operating frequency range is 50 to 400 cps.



Circle No. 161 on Subscriber Service Card

Automatic Check-Out Tester

The Model CT-1 automatic checkout tester for electronic and electromechanical equipment and components is being marketed by Dimensions, Inc.

The self-checking unit initiates a process or cycle with an electrical or mechanical signal and receives a signal from equipment under test signifying satisfactory operation. Number of initiations and responses are separately counted. The device has operating speeds up to 50 cps (180,000 cph). Life exceeds 100 million cycles. Double and tripple redundancy is available for extra reliability. Input is 117v ac.

Circle No. 162 on Subscriber Service Card

Digital Clock

Dymec Div. of Hewlett-Packard Co. is marketing the DY-2509A digital clock, which provides time information as a continuous 24-hr. visual display and an electrical output available on demand for recording purposes.

The solid-state instrument has pulse outputs available at precise intervals for timing external functions. A front-panel pushbutton provides output interval selection of a pulse every one second, 10 sec., one min., 10 min. or one hour.

Circle No. 163 on Subscriber Service Card

VHF Transistor

A 12-v VHF communication transistor for mobile and portable equipment has been introduced by TRW Semiconductors, Inc., a subsidiary of Thompson Ramo Wooldridge, Inc.

The Model PT4800 planar epitaxial silicon transistor delivers a 1-watt minimum output at 70 mc from a 12-v power source with greater than 50% efficiency. Typical power gain at 70 mc is 7 db. Substantial RF power output can be obtained from supply sources as low as 6v. The device has a TO-5 package.

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Miami, Florida 33132

Circle No. 16 on Subscriber Service Card

Tapped Delay Line

The Model 53-63 delay line, featuring a maximum time delay of 20.3 μsec and taps at 1.45-μsec intervals, is available from ESC Electronics Corp.

Three trimming sections of 0.02, 0.03 and 0.05 μsec permit precise adjustment of the main delay line. The unit has a rise time of 0.20 μsec maximum, impedance of 470 ohms, and an attenuation of 6 db maximum with a 10-K load at each tap. Delay tolerance is ±0.03 μsec and spurious response is 10% maximum at any tap.

Circle No. 165 on Subscriber Service Card

In-Line Vernier Attenuator

An in-line vernier attenuator designed to provide for fine control of attenuation when used as a separate unit or in series with 1.0-db step attenuators has been announced by Kay Electric Co.

The device provides attenuation values in 0.1 steps from 0.1 to 1.1 db at frequencies up to 500 mc. Typical accuracies exceed ±5% overall at 100 mc; ±10% at 250 mc. Maximum VSWR is 1.4 at 250 mc. Units are available in 50, 70 and 90 ohms.

Circle No. 166 on Subscriber Service Card

Mercury-Wetted Relay

A line of "short can" mercury-wetted relays measuring 1.875 in. in height has been introduced by Babcock Relays, a division of Babcock Electronics Corp.

The BW-3 series features a temperature range of —37° to 107° C and a life expectancy of more than one billion cycles. The units operate at speeds as high as one millisecond and on power as low as 1.2 mw. Contact breaking acceleration is 1,500 g's.

Other specifications include a maximum power dissipation of 1.5 watts and a maximum contact resistance of 40 milliohms.

Circle No. 167 on Subscriber Service Card

Logarithmic Spiral Antennas

Dorne & Margolin, Inc., is marketing two omnidirectional, elliptically polarized antennas, designed for the missile/space industry.

The Models AR18 and AR19 logarithmic spiral antennas cover the frequency range from 250 to 10,000 mc and provide complete omnidirectional coverage when used with appropriate broadband, directional antennas.

AR18 has an operating range of 250 to 1,000 mc; AR19 from 1,000 to 10,000 mc. Axial ratio of polarization ellipse is less than 2 to 1; VSWR is less than 2 to 1 for the entire band.

Circle No. 168 on Subscriber Service Card

Solistron

Western Microwave Laboratories is marketing the solistron, a microwave source that provides solid-state klystron performance.

The unit features single-knob mechanical tuning to 10% of bandwidth and electronic tuning to 4% bandwidth. Power outputs from 3 to 100 milliwatts are available with single-voltage power supply requirement of 1 to 20v. Models are available in the 900-mc to 3-gc range.

Circle No. 169 on Subscriber Service Card

Power Transformer

Abbott Transistor Laboratories, Inc., is marketing a line of hermetically sealed power transformers designed exclusively for 400 cycles.

The Model 175E, a 175-watt series, measures 2.7 x 2.7 x 2.25 in. and is capable of operation at temperatures up to 105°C. The unit meets MIL-T-27A specifications. Primary voltage on standard units is 115v, 400 cps ±20 cps, 1 phase, with secondaries available from 5 to 5,000v ac, 175 watts.

Circle No. 170 on Subscriber Service Card

Opportunities In . . .

MELPAR'S EXPANDING AEROSPACE DIVISION

for Supervisory and Technical Personnel

These positions result from the constant growth of our programs and possess excellent potential for personal advancement.

AERONAUTICS

Projects have both atmospheric and space applications and work includes preliminary design for configurations, drag estimation, stability and control parameter estimation, validation and detail of design by wind tunnel testing, and participation in trajectory studies to assure capability for the mission. Capability for structural analysis (vibration and flutter) is also needed. MS Degree level of competence is desired.

GUIDANCE AND CONTROL

Projects have both atmospheric and space applications and include analysis in both linear and non-linear systems. Some knowledge of the mathematics of optimum controls is desirable as is familiarity with the use of analog and digital computers in solving guidance and control problems. MS level of capability is desired.

OPERATIONS ANALYSIS

To perform operations analysis of complex military and space systems including trade-off studies on sub-system requirements and costs, leading to assessment of the technical and cost effectiveness of the total system. Knowledge of probability theory and its uses as well as use of digital and analog computers is required. MS level of competence desired.

SYSTEM TEST & INSTRUMENTATION

To conduct tests (including field tests) with special emphasis on telemetry systems. Familiarity with range of techniques and equipments for sounding rockets and probes in a developmental program is required.

PROPULSION

Assignments will include preliminary design of small, high performance solid propulsion systems. Problems include grain, case and nozzle design, specifications writing, and technical participation in developmental subcontracts. Knowledge of the use of analog and/or digital computers is essential as is knowledge of the present state-of-the-art. MS level preferred.

For details, write in strictest confidence to:

John A. Haverfield, Manager—Professional Placement

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Circle No. 13 on Subscriber Service Card

M/R BUSINESS OFFICES

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A. C. Boughton, National Sales Manager
Craig L. Mason, Director of Research

New York, N.Y., 10017—20 East 46 Street; YUkon 6-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, California, 90210—9301 Wilshire Blvd.; CRestview 4-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

Detroit, Michigan—21990 Greenfield Road, Oak Park, Mich., 48237; 547-8880
Michael Rouff

Chicago, Illinois, 60601—1 East Wacker Dr., Room 1522; 321-1444
Charles E. Durham, Jr.

Miami, Florida—P.O. Box 890, Hollywood, Fla., 33022; WIlson 7-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

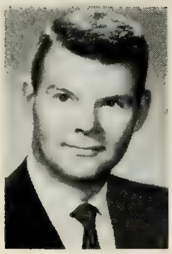
Geneva, Switzerland—10 Rue Grenus; Geneva 321044

Paris, France—11 Rue Condorcet; TRU 15-39

names in the news

CARTER

MILLER



MITCHELL

THURMAN

Thomas J. Carter: Appointed manager of international and commercial marketing for United Technology Center, Sunnyvale, Calif.

Roger Damm: Appointed marketing services manager at Motorola Semiconductor Products, Inc., Phoenix.

Dr. Carl L. Frederick: Named manager of the Washington, D.C. district office of HRB-Singer, Inc.

Gerald Miller: Named manager, sales planning and promotion at Memorex Corp., Santa Clara, Calif.

Harold Rapaport: Promoted to executive vice president and general manager of ITT Kellogg Communications Systems Div., New York City.

Jack J. Marks: Joined Northrop-Ventura, Newbury Park, Calif., as assistant program manager, *Apollo* Earth landing system.

F. Eugene Newbold, Jr.: Appointed assistant general manager of the Wright Aeronautical Div., Curtiss-Wright Corp., Wood-Ridge, N.J.

Joseph K. Mann: Joined Eitel-McCullough, Inc., San Carlos, Calif., as a senior project engineer in the high power microwave laboratory.

Charles A. Mitchell: Appointed director of planning for the Geophysics Corp. of America, Bedford, Mass.

John P. Thurman: Named small business administrator for North American Aviation's Los Angeles Division.

Frederick W. Howells: Appointed director of the Washington, D.C. Research Center of Technical Operations Research, Burlington, Mass.

Courtland D. Perkins: Chairman of the Dept. of Aerospace and Mechanical Sciences at Princeton University, elected 1964 president of the American Institute of Aeronautics and Astronautics.

A. L. Feldman: Appointed assistant plant manager in charge of Aerojet-General Corp.'s liquid rocket plant production programs, Sacramento, Calif.

Edwin L. Rule: Named vice president-manufacturing of Hexcel Products, Inc., Berkeley, Calif.

Caleb B. Hurtt: *Titan I* program director for the Martin Co.'s Denver Div., awarded a public affairs fellowship by the Brookings Institution for Advanced Study in Washington, D.C.

Richard B. Mulock: Named manager of product assurance at Lenkurt Electric Co., Inc., San Carlos, Calif.

Dr. T. A. Neely: Named director of research and engineering at the Huntsville, Ala., plant of Thiokol Chemical Corp.'s Alpha Div.

Edwin J. Kirschner: Appointed director of research and development at Embry-Riddle Aeronautical Institute, Miami.

Dr. Mark K. Smith: Appointed executive vice president of Geophysical Service, Inc., a subsidiary of the Science Services Div. of Texas Instruments, Inc., Dallas.

Harold Desmond Shelley: Named sales engineer for telemetry and surveillance equipment at Vitro Electronics, Silver Spring, Md.

Ralph W. Rawson: Elected president and a member of the board of directors of Firth Sterling, Inc., Pittsburgh.

Robert Landon: Appointed manager of advertising and public relations for Eitel-McCullough, Inc., San Carlos, Calif.

Milton V. Richards: Appointed marketing manager-Air Force programs for Philco Corp.'s TechRep Div., Washington, D.C.

Jack I. Hamilton: Resigned as vice president and executive assistant to the president, Menasco Mfg. Co., Burbank, Calif., and Fort Worth, Tex.

Bruce G. Oldfield: Appointed vice president, space programs and field operations in the IBM Federal Systems Div., Rockville, Md.

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JANUARY

AIAA Solid Propellant Rocket Conference, Palo Alto, Calif., Jan. 29-31, (semi-classified).

American Meteorological Society, 44th Annual Meeting, University of California at Los Angeles, Jan. 29-31.

FEBRUARY

American Institute of Chemical Engineers, 52nd National Meeting, Hotel Peabody, Memphis, Tenn., Feb. 2-5.

IEEE Winter Power Meeting, Statler Hilton Hotel, New York City, Feb. 2-7.

International Congress on Documentation and Scientific-Technical Information, Rome, Italy, Feb. 2-11.

International Conference on the Impact of Modern Physics on Materials, Sheraton Hotel, Philadelphia, Feb. 3-7.

IEEE-MIL Fifth Winter Convention on Military Electronics, Ambassador Hotel, Los Angeles, Feb. 5-7.

American College of Radiology National Meeting, Tucson Ariz., Feb. 5-8.

Institute on Information Storage and Retrieval, sponsored by American University, International Inn, Washington, D.C., Feb. 10-14.

Golden Gate Metals Conference, American Society for Metals, Fairmont Hotel, San Francisco, Feb. 13-15.

1964 Annual Meeting and Symposium on Physical Metallurgy of Refractory Metals, sponsored by AIME, New York City, Feb. 16-20.

ASCE Transportation Engineering Conference, Netherland Hilton Hotel, Cincinnati, Ohio, Feb. 17-21.

International Solid State Circuits Conference, sponsored by IEEE and the University of Pennsylvania, Sheraton Hotel and University of Pennsylvania, Philadephia, Feb. 19-21.

9th Scintillation and Semiconductor Counter Symposium, sponsored by IEEE, AEC and NBS, Shoreham Hotel, Washington, D.C., Feb. 26-28.

MARCH

ASME Gas Turbine Conference and Products Show, Shamrock Hilton Hotel, Houston, Mar. 1-5.

Atmospheric Problems of Aerospace Vehicles, sponsored by FAA and AMS, National Aviation Facilities Experimental, Atlantic City, N.J., Mar. 2-5.

15th Pittsburgh Conference on Analytical Chemistry and Applied Sprectroscopy, Penn-Sheraton Hotel, Pittsburgh, Mar. 2-6.

Fifth Symposium on Thermal Radiation of Solids, Sheraton-Palace Hotel, San Francisco, Calif., Mar. 4-6.

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An Adequate Budget

IT IS NOW UP TO CONGRESS to determine whether this nation will have a Fiscal 1965 missile/space budget adequate to its needs. President Johnson has sent to the Hill a sharply pruned budget for missile and space activities.

If the Congressional committees holding authorization and appropriations hearings accept as sincere the effort of the Administration to hold the line on spending, the funding of missile/space programs will remain approximately at the same level as in the current fiscal year. At this time, it is an acceptable level from the standpoint of the nation's requirements.

The pruning by the Presidential shears has been a careful one, allowing those programs to grow which are most vital, cutting back those where delay can be accepted. Congress, however, can wreck the entire effort if it does not recognize this approach. The Johnson budget cannot withstand massive cuts of the kind made in the FY '64 Dept. of Defense authorization or the rough treatment accorded the National Aeronautics and Space Administration budget last year.

It can be anticipated that the FY '65 budget for DOD will be more acceptable to Congress than its predecessor. The new obligational authority requested is $2.7 billion less than sought last year and, at $50.9 billion, just about on a level with the $51 billion provided by Congress for FY '64. Since President Johnson shrewdly has decided to seek a '64 supplemental to cover the military pay increase, this means new money available in the DOD budget should total about the same as last year.

Most of the reduction in funding requests for missile/space activities can be attributed to the anticipated peaking-out of the nation's ICBM requirements. Missile procurement drops from $4.108 billion to $2.988 billion in the new budget. Missile RDT&E drops from $2.117 billion to $1.851 billion.

The *Minuteman* program calls for 50 new silos of *Minuteman II's*, less than the Air Force had hoped to add. This is offset, however, by the decision to retrofit 800 silos for the *Minuteman II*, which has longer range, a heavier payload and multiple target capability. The ICBM forces of *Titans*, with *I* and *II* all now operational, will remain at the same level. The *Atlas* force will decrease somewhat with phase-out of the first-generation *Atlas D*.

Further drop in the missile budget is accounted for by completion in the Fiscal '64 budget of funding for the 41 *Polaris* submarines.

All of these reductions could be anticipated; they represent no shock to the industry's financial well-being.

A top Dept. of Defense official says a decision will be made this calendar year on whether to initiate procurement of *Nike-Zeus* and *Nike X*, a move that could cost from $12 billion to $20 billion in the years ahead. As we pointed out several weeks ago, if the decision is favorable initial funds for this will be sought in the FY '66 budget. The decision will depend not only on progress of *Nike X* but also on how the Soviet ICBM buildup proceeds.

Other missile activity continues. Troubled *Mauler* drops back into R&D, but *Shillelagh* will move out of program definition, improved versions of *Sidewinder* and *Bullpup* are funded, procurement of the operational *Pershing* continues, and there is new life for *MMRBM*. These, and others, add up to an active year in the missile field.

There are, moreover, significant studies under way which bode well for future missile development. Some $5 million is allocated for the study of a missile platform aircraft which will require a new missile, possibly of the *CLAM* or *SLAM* nature. Work on *SLAM*, the nuclear supersonic low-altitude missile, will be continued with some $20 million divided between the Atomic Energy Commssion and DOD budgets. There also will be funds for study of advanced land- and sea-based ICBM's.

The budget for military space drops slightly this year. This plateau in military space spending should not be of concern, however. The $140-million reduction results from the *Dyna-Soar* cancellation and the peaking-out of *Titan III* funding in the Fiscal '64 budget. Secretary of Defense McNamara's initiation of the *Gemini-X* and *Manned Orbiting Laboratory* programs carries assurance of considerable Air Force activity in this field, to be reflected by sure growth of the DOD space budget.

ALTHOUGH IT CAN BE EXPECTED that passage of the DOD budget will be smoother, due to an effective cost reduction program and other economies, the NASA budget once again faces rugged going. Congress must understand, therefore, that the economic pressure on the FY '64 budget has had its effect. Administrator James Webb considered his last budget austere and, to him, this one smacks of downright starvation.

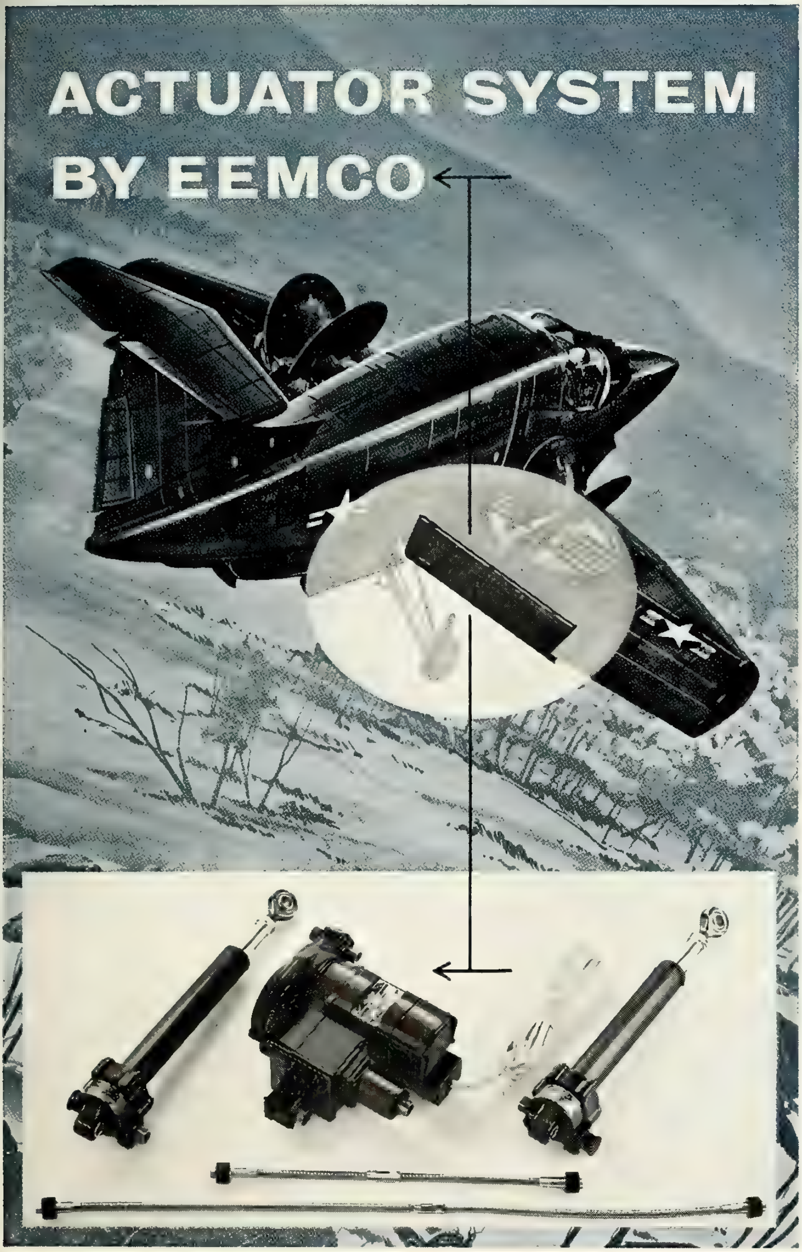
The manned lunar landing program, as before, will get the roughest treatment. In regard to this, Associate Administrator Robert Seamans says "we are now cut back to the point that we cannot carry out the program unless we get the full support of Congress, and even then we will have no time to fall back on."

An examination of the NASA budget shows that it has indeed been pared to concentrate on the *Apollo* program. Funding for *Apollo* is peaking now, and the space agency is cancelling or delaying a number of unmanned projects to keep the lunar program moving. These cuts have been substantial, have been achieved at the cost of some dissension in the agency, and should be accorded due recognition by Congress. *Ranger* has been slashed from $52 million to $10.8 million, the *Nimbus* weather satellite from $41.2 to $18.9 million, RIFT from $7.5 million to zero, Project Fire from $8 to $3 million. These are but a few of the cutbacks.

Congress, in its last examination of the NASA budget, demanded some harsh economies. It should acknowledge that this demand has been heeded and that the fat has been trimmed out of the budget sent to the Hill. There should be a thorough examination of the NASA budget, certainly, but with the knowledge that any deep cuts can damage severely the nation's vital space program.

William J. Coughlin

ACTUATOR SYSTEM BY EEMCO



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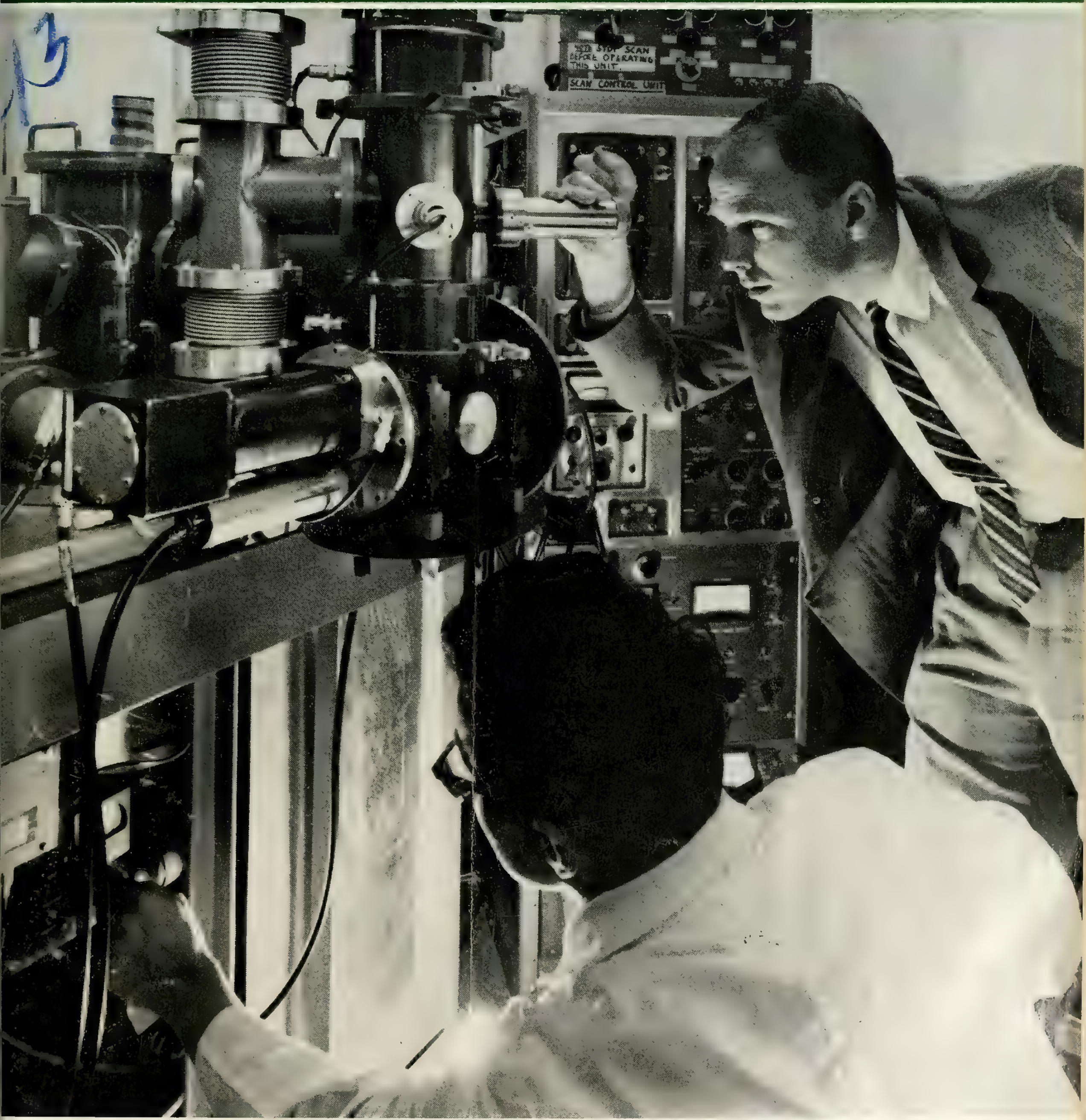
missiles and rockets

HE WEEKLY OF SPACE SYSTEMS ENGINEERING

13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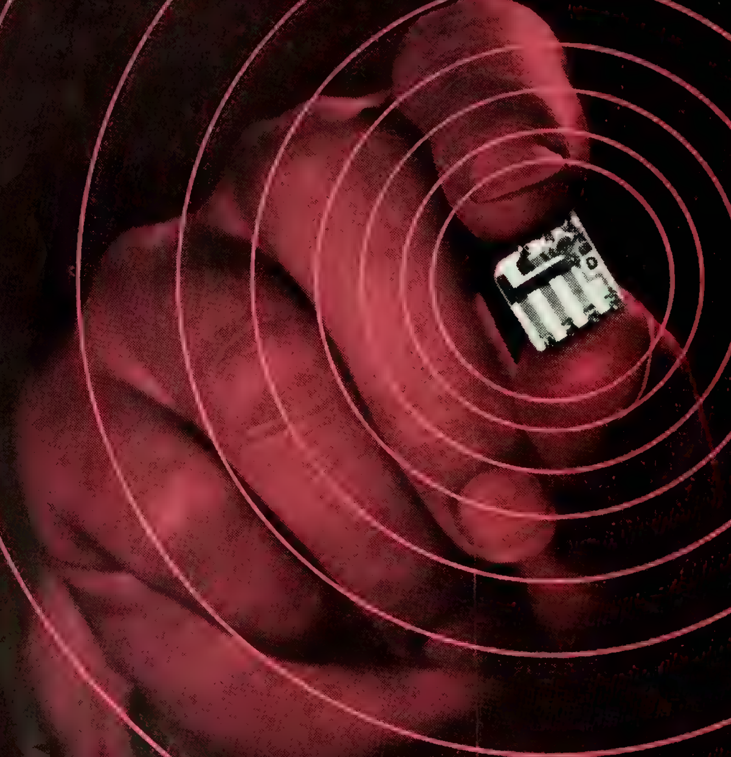
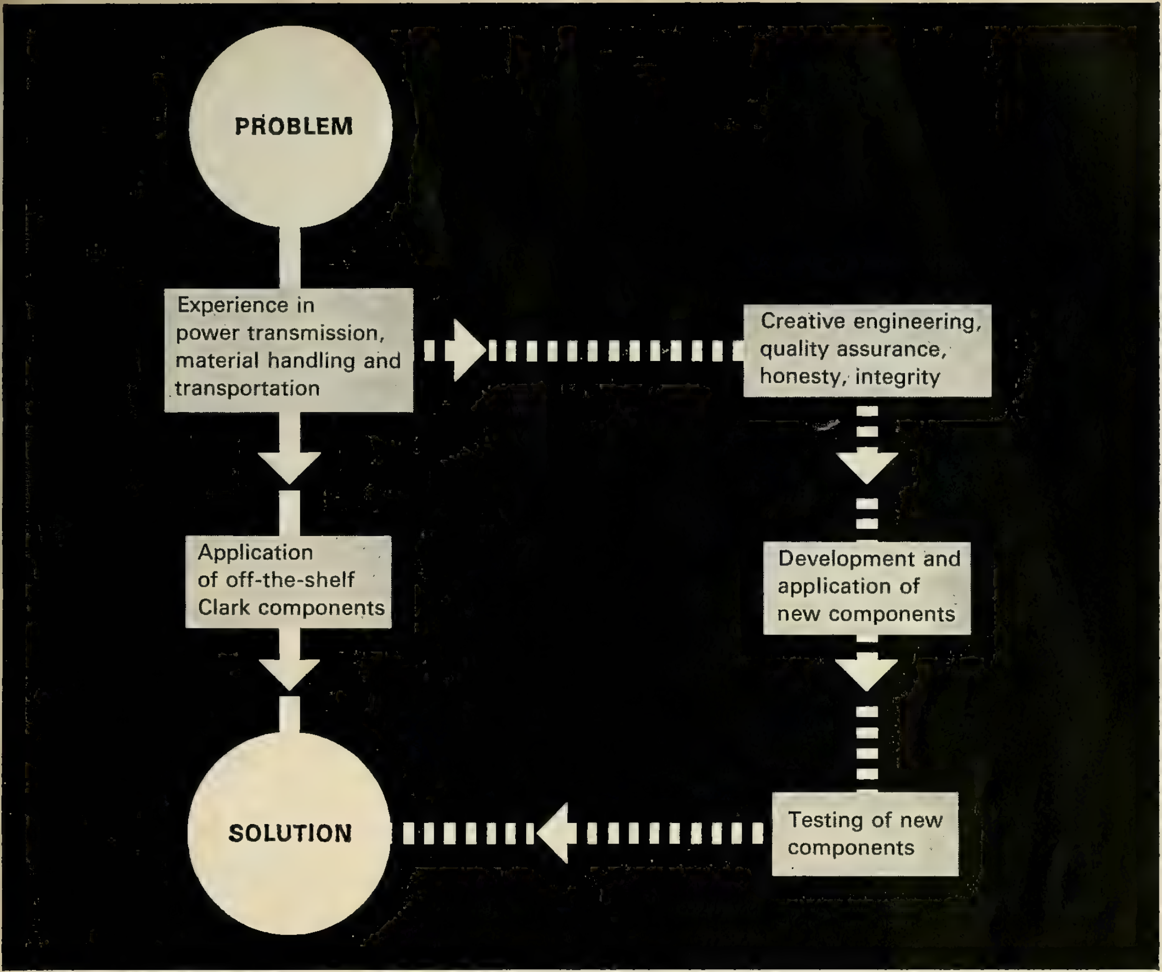


New Lockheed-developed titanium technology simplifies fabrication, cuts equipment and camera costs, requires no special operator skills.

Here is an economical, established method for manufacturing thin-film circuits and components that utilize titanium and titanium dioxide. It is ideal for an aerospace company that wants in-house capability — as well as for present manufacturers who want to upgrade quality, increase production, and lower costs. For information about the process and licensing arrangements for its use, please write: The Patent Office, Lockheed Missiles & Space Company, Sunnyvale, California.

Lockheed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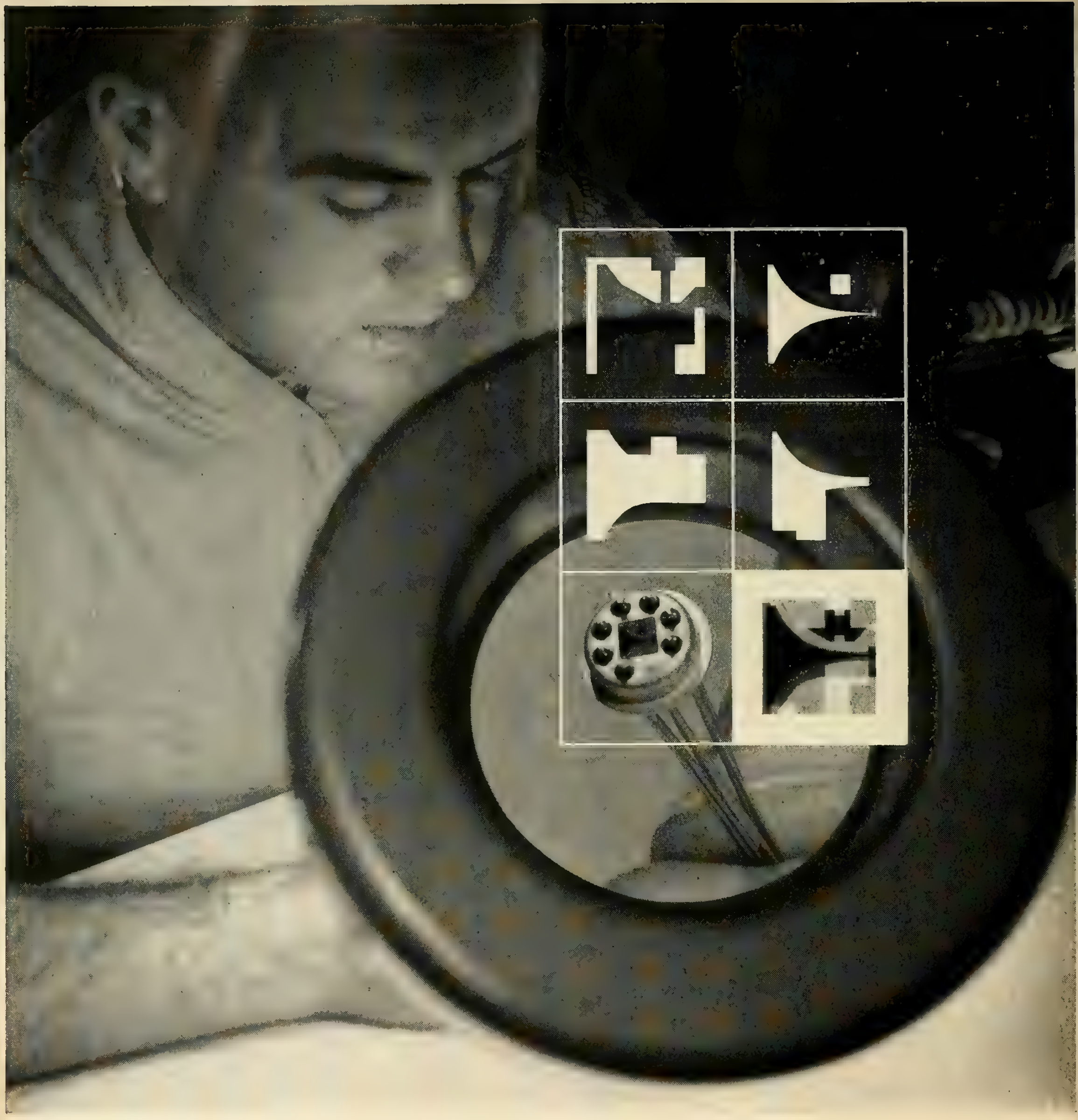

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Microminiature thin-film circuitry research is one of the many advanced areas of electronics activities at Boeing's Aero-Space Division.

Engineers in the Division's electronics techniques organization superimpose a series of film shapes as thin as 1/4,000,000th of an inch, to create a complete electronics network. A microminiature network, measuring 1/10″ square, is shown magnified above, mounted on a header.

Boeing microminiature electronics capabilities include development of circuits on silicon transistor chips, vacuum deposition of thin-films and mathematical analysis of circuits.

In all, more than 4,000 Aero-Space Division employees are engaged in electronics at Boeing, including systems design and production work for Minuteman ICBM, Saturn S-1C, HiBEX, hydrofoil research craft and the lunar orbiting satellite.

BOEING

AERO-SPACE DIVISION

missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING Volume 14, Number 5 February 3, 1964

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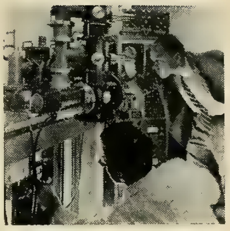

First successful scanning electron microscope in U.S. is this Westinghouse Research Labs' device that "sees" with a thin electron beam. The instrument aids in detailed studies of the intricate surfaces of molecular electronic blocks and other microelectronic components. M/R's special report on microelectronics begins on page 22.

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letters

The Incentive Game

To the Editor:

Much too difficult a temptation to resist is some comment on your article and editorial, "The Incentive Game" (M/R, Jan. 20).

If "the profit motive is the spark plug of the free enterprise system" and if "The Incentive Game" provides increased profits for lower costs and/or better performance for government contractors, then as surely as God made little green apples the involved products are designed or invented by the employed engineers of those contractors who have no incentives and no piece of the involved action.

Just as surely, those engineers and inventors would be galvanized into heroic action for the benefit of both the government and the contractors, if they themselves shared only to some small degree in the incentive game. Bread and butter alone will never stimulate their highest performance.

Benjamin F. Miessner
Miami Shores, Fla.

'Torr' Defined

To the Editor:

In your Nov. 25 NASA issue, in an article entitled "Goddard Aims to Build Even Bigger Test Facilities" (p. 197), you mention several times the word "torr" as a unit of measure for pressure and/or vacuum. We presume this to be related but not necessarily identical to millimeters of mercury at standard temperature of 70°F and relative humidity conditions of 60%. To clear up this point, will you please supply me with a precise definition of the term "torr"?

G. A. Ostrom
Abbottstown, Pa.

Torr—named in honor of Torricelli, Italian scientist who invented the barometer—is the pressure exerted by a column of mercury one millimeter high at 0°C, 45 degrees latitude at sea level (standard gravity).—Ed.

Centaur Oversight

To the Editor:

I find rather amusing your reference to the Astrolog as a "current status of U.S. missile and space programs." In the Jan. 13 M/R, you make the following observation under "status" with respect to the *Centaur* program:

> Development; program responsibility transferred from MSFC to Lewis; first flight test failed; late 1964 or early 1965 earliest possible operational date; next launch November, 1963.

Strides forward in the U.S. space program on Nov. 27, 1963, with the first successful launch of the *Centaur* space vehicle seem to be of significant merit to cause you to update your "log" on a more reliable basis.

R. G. Newell
St. Petersburg, Fla.

Launch of Centaur Nov. 27 was duly reported in M/R's Dec. 9 issue, but slipped by Astrolog. It is covered in an Errata sheet with Astrolog reprints. —Ed.

Saturn Gaseous Helium

To the Editor:

On page 15 of the January 13 issue you describe our *Saturn* Helium Bottle Program.

The last sentence contains an error which I would like to correct. The bottles described will contain *gaseous* (not liquid) helium at 3,000 psi. The bottles are mounted inside of the liquid oxygen tank, and four are required for each *Saturn V* first stage.

Richard A. Hirsch
Technical Director
Saturn Helium Bottle
Program
Martin Company
Baltimore

'Profile Of An Industry' Reprints

IN RESPONSE to widespread reader interest, Missiles and Rockets *has prepared reprints of the three-part "Profile of an Industry" series by Senior Editor William Beller. Based on recent surveys by U.S. Government agencies and the Stanford Research Institute (under a contract from the Aerospace Industries Association), the articles first appeared in the Oct. 28, Dec. 2 and Dec. 16, 1963, issues of M/R. Together they provide an unprecedented report on the growth of the Missile/Space industry—now the second largest employer in the United States—and its impact on the national economy and technology.*

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THE SKEPTICAL MEN AND THE MICROELECTRONIC COMPUTER Perfection is a microcosm. Its pathways today are often the branches of intricate electronic circuits—so small that few can conceive of them. But there are some who probe these pathways with growing confidence: the creative electronics scientists of aerospace.

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Throughout the industry, men like these are exploring the mazes of perfection. In the courts of their minds, even perfection itself is always on trial, and acquittal is never final. For these are the skeptical men.

North American Aviation is at work in the fields of the future through these divisions: Science Center, Atomics International, Autonetics, Columbus, Los Angeles, Rocketdyne, Space & Information Systems.

The Countdown

WASHINGTON

ARPA Spending Plans

About 50% of the $128 million requested for ARPA's Project Defender for FY '65 will be used for a study of missile re-entry phenomena, including full-scale experiments in the Pacific. It will also be concerned with development of penetration aids for the U.S. strategic retaliatory missiles.

AF Expands Range Funding

The Air Force is requesting $231 million in FY '65 funding for the Atlantic Missile Range. Budgets for the other ranges include $159 million for operation of the Pacific Missile Range and $93 million for White Sands. By the end of FY '66, the Air Force will have completely taken over operation of Point Arguello, ICBM impact area stations and the space tracking stations in the Pacific.

New Eye to Submarine Threat

DOD is getting ready to modify some air-defense radars on the East, West and Gulf Coasts to give them some capability against shorter-range missiles launched by submarines, thereby providing at least a few minutes of warning. About $16 million will be spent on the program in the next fiscal year and money requirements are expected to extend for a year later.

FLOXing Approach Pondered

NASA expects to make a decision within a month on the type of feasibility program it will follow as it explores the fluorine/oxygen-fueled *Atlas* booster. A good possibility now is a move to a heavy engine test program, with much of the work being done by the Marshall Space Flight Center. This would put off the first flight of a FLOX *Atlas* for at least two years. Some agency officials feel that this approach—rather than a direct move to a flight test program—could be cheaper by a factor of 10 to 1. It could also provide valuable data on the possibility of fluorine/oxygen *Thor* and *Saturn* boosters, because they use what is essentially the same liquid Rocketdyne engine used in the *Atlas*.

New Satellite Series Studied

Studies of NASA's new *Advanced Technological Satellite* program will be completed March 1. The big question is how much of the previously obtained information on the *Advanced Synchronous Satellite* can be used for the new spacecraft series. The satellite is expected to weigh about 600 lbs. and will be launched by an *Atlas-Agena* with a heavy apogee kick motor. Final decision on a procurement plan for the program will not be made until after the study is evaluated and completed.

Over-the-Top Radar in Trials

DOD now has a prototype of an over-the-horizon radar in operation. If successful the radar could be used as a backup to BMEWS. It would be able to detect missiles attacking from any direction, provide earlier information on missile raids than BMEWS and provide greater confidence by confirming BMEWS warnings.

Lacrosses Being Replaced

The Army has decided to eliminate six battalions of *Lacrosse* missiles. The reason—rapid introduction of other weapons such as the improved *Honest John*, the 175mm gun and the new eight-inch howitzers.

Anti-Shark Measures for Cameras

On-board cameras of *Saturn SA-5* (see p. 18) were painted blue and carried shark repellent to protect them from marine life after ejection into the ocean. A number of *Discoverer* capsules dropped into the Pacific appear to have been chewed up by sharks or porpoises. Marine biologists doubt the efficacy of shark repellent, but it makes the pararescue divers feel better during the long wait for a recovery ship.

INDUSTRY

Reticle May Spot Enemy Satellites

Boeing is studying a simple visual aid to help distinguish non-cooperating satellites from the star background. It is a telescope reticle with many parallel opaque lines. A spacecraft whose motion is undetectable with the naked eye will appear to twinkle as it passes through the open spaces on the reticle. If the scope is attitude-stabilized with precision, the relatively stationary stars will show as steady sources.

New Photochromic Glass Offers Spacecraft Uses

Corning Glass Works scientists report development of a new photochromic glass which can retain permanently its ability to darken when exposed to light, then clear when the light source is removed. They believe it may be used in spacecraft windows and in control and detection instruments. The glasses are reported to respond primarily to the near ultraviolet, but can be altered somewhat to other spectrum areas. Corning says they are melted and formed by conventional glassmaking methods, and composed of silicate glasses containing submicroscopic silver halide crystals.

Long Life Predicted for Syncom RCS

Analysis of the hydrogen peroxide reaction control system (RCS) aboard *Syncom II* indicates that the system could continue to provide control capabilities for orbital adjustments for another 10 years. The Hughes-built satellite, launched last July, thus far has received more than 2,030 pulsed bursts from the RCS. The 3.35-lb. system, carrying a 5-lb. charge of 90% hydrogen peroxide plus 0.18 lbs. of nitrogen pressurant gas, was supplied to Hughes by the Aerospace Div. of Walter Kidde & Co., Inc.

INTERNATIONAL

Europeans Propose Dyna-Soar Project

More than 100 representatives of European electronics and aeronautical firms met in Brussels Jan. 23-24 and discussed feasibility of a joint transporter project for manned commuter service from Earth to U.S. and Russian space laboratories. Participants said they felt that the recent U.S. cancellation of the *Dyna-Soar* program gives Europe a chance to fill a void in Soviet and American plans. Prof. Eugen Saenger headed the German delegation, and Prof. Maurice Roy was a member of the French group. Britain was also well represented.

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The Missile/Space Week

Echo Status Not Clear

At the middle of last week, the question of whether the 135-ft. *Echo II* balloon was collapsing remained. Pictures taken Jan. 25 by a television camera mounted in the upper stage of the *Thor-Agena B* launch vehicle indicated that, although the sphere had inflated as planned, gas began leaking out after two hours. It had been hoped that the balloon would maintain its internal pressure for 20 hours, long enough to permit the aluminum and plastic structure to become rigid.

The balloon previously bounced back radio messages between stations in Rome, N.Y.; Columbus, Ohio; Dallas, Tex.; and Stump Neck, Md.

Further indications of the balloon's failure to hold its shape came in the form of occasional radar observation "dropouts." These apparently were caused by variations in the reflective qualities of the balloon, such as might be caused by incomplete inflation.

However, optical observations indicate that *Echo II* is still holding its shape. NASA said it was possible that radar observations might be disturbed in some way, such as by the upper stage of the rocket orbiting near the satellite or the inflating gas's becoming electrically charged.

The actual condition of the satellite will have to be determined by extensive radar studies since optical telescopes are not powerful enough to provide an accurate picture.

The actual launch of the balloon, in a 30 x 40-in. pod in the nose of the booster, was considered highly successful. The 535-lb. satellite has an apogee of 816 mi., a perigee of 642 mi. and an inclination of 81.5 degrees from the equator. Orbital period is 109 minutes.

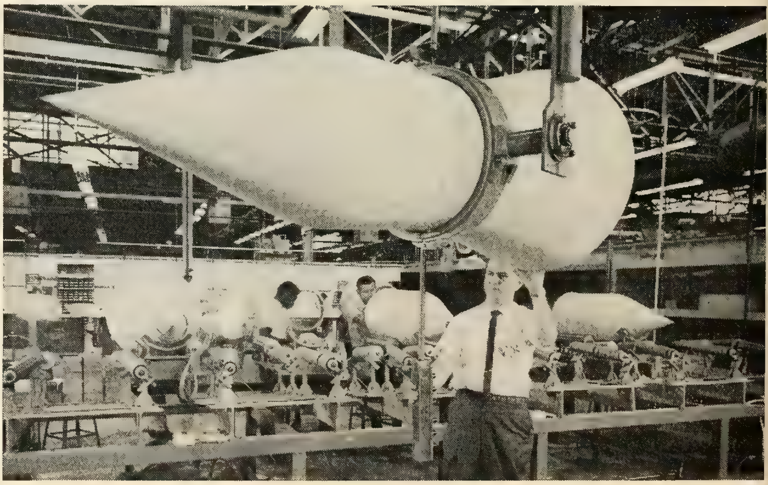
Shots of the Week

After an embarrassing scrub on Jan. 27, *Saturn SA-5* was successfully launched from Cape Kennedy on the 29th (see p. 17).

Echo II was lofted into orbit by a *Thor-Agena B* booster on Jan. 25 from Vandenberg AFB, Calif., (see story above).

Other shots of the week:

- The Air Force successfully launched a *Titan II* ICBM from an underground silo at Vandenberg AFB, Calif., Jan. 23. Shot went 5,000 mi. down the Pacific Missile Range.
- The atomic submarine Nathan



Minuteman Mark 11 Re-entry Vehicles in Assembly

AVCO CORP'S Mark 11 re-entry vehicles for the Minuteman ICBM shown in final assembly stages at firm's Lycoming Div., Stratford, Conn. Advanced versions of the missile use the Mark 11, which incorporates special ablative heat shield materials developed by Avco. The earlier Mark 5 Minuteman re-entry body and the Mark 4 Titan/Atlas re-entry vehicles also used Avco-developed ablative materials.

Hale launched two *Polaris A2's* from beneath the Atlantic near Cape Kennedy Jan. 26. One was a success, the other was destroyed by the range safety officer when it veered off course after second-stage ignition. Both shots utilized the Navy's new steam ejection system.

- The Air Force on Jan. 28 fired the third and last interim *Minuteman* vehicle, a Wing II version with a Wing VI second stage, from Cape Kennedy. Shot was 30th success in 45 attempts with *Minuteman* from Cape Kennedy.
- NASA's *X-15* made its 100th flight Jan. 28 from Edwards AFB, Calif. Air Force Maj. Bob Rushworth piloted the rocket plane in the flight to test a new paint designed to protect the craft from re-entry heating.

Hornig Sworn In

Dr. Donald F. Hornig was sworn in Jan. 24 as Special Assistant to President Johnson for Science and Technology.

Formerly chairman of the chemistry department at Princeton University, Hornig will also serve as chairman of the Federal Council for Science and Technology and director of the White House's Office of Science and Technology.

He succeeds Dr. Jerome B. Wiesner, who served as Presidential scientific adviser for three years.

DOD Acts to Conserve Skills

The Defense Dept. has announced a new policy aimed at retaining skilled teams of scientists, engineers and technicians after cancellations of major projects, such as *Dyna-Soar*.

A spokesman for the Defense Dept. said the move would insure that an "ever greater effort is devoted to preservation of human skills."

Under the policy, work on a project would be cut back gradually instead of effecting an abrupt and total cancellation. Phases of use elsewhere would be continued, the spokesman said.

The Army, Navy and Air Force were ordered to exclude from contract termination "work of continuing value to the Government."

AEC City Delayed

The Atomic Energy Commission has requested that the Joint Committee on Atomic Energy take no

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The completely-modular unit has been specially-designed by DEI to accept inexpensive plug-in sub-assemblies . . . seven RF tuning heads . . . nine IF amplifiers and four demodulators . . . to cover all presently-assigned frequencies in the VHF/UHF spectrum.

The TMR-6 features crystal control of both oscillators, extremely low noise figures and can be adapted for use in PM systems by means of a phase-locked loop around the entire receiver. It is capable of tracking any frequency change introduced by Doppler shift, transmission and reception instabilities up to 0.007 per cent of the received frequency.

This versatile, low-cost receiver also accepts plug-in modules for pre-detection recording of either AM or FM with existing stationary head video tape recorders.

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further action at this time on proposed legislation that would provide for a new community near the Nuclear Rocket Development Station in Nevada.

The AEC, with the approval of NASA, made the request following a reconsideration of the need for such a community and in the light of the reorientation of the joint AEC-NASA nuclear rocket development (Rover) program.

More on Missile Dependability

President Johnson and Defense Secretary Robert S. McNamara, in separate statements last week, re-emphasized the reliability of the nation's missile arsenal.

Secretary McNamara told the House Armed Services Committee that the U.S. missile force "can be depended upon to carry out its military mission under all the conditions we can foresee." Results of a missile attack on an enemy can be predicted with greater confidence than those of a bomber attack, he added.

In the Administration's report to Congress on 1963 U.S. space activities, the President emphasized the "reliability" of both space and military rockets. Johnson's report cited NASA successes in 14 of 15 launch attempts, including a 10-for-10 score on Earth satellite tries.

Renegotiation Backlog Cut

The Renegotiation Board, striving to dispose of most of its cases within 50 to 60 days after receipt, is trying to better its last year's record of concluding 86.4% of its filings within 66 days, Lawrence E. Hartwig, Board chairman, has told MISSILES AND ROCKETS.

Urging other government agencies to match the Board's record, Hartwig pointed out that in Fiscal 1963, 3913 new cases were filed and 4068 processed, thereby cutting significantly into the Board's backlog. In fiscal 1962, 3228 or 89% of the 3618 filings were disposed of without subsequent assignment to a regional board.

NASA Gets New Tracking Site

Spain and the U.S. have agreed to the construction of a Deep Space Tracking station 30 miles west of Madrid.

The new installation will have an 85-ft.-dia. parabolic antenna as well as equipment for spacecraft data handling and communication.

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SPACE AND INFORMATION SYSTEMS DIVISION
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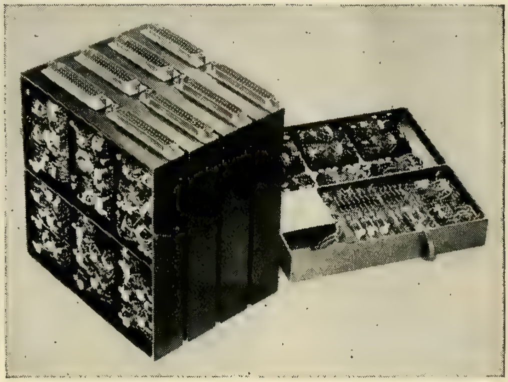
3C SPACEBORNE DATA CONDITIONING SYSTEMS

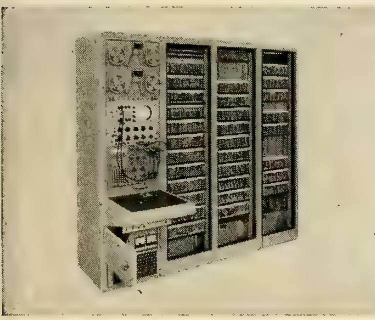
Successful 109-day Venus probe leads to advance-design systems for unmanned exploration of Mars

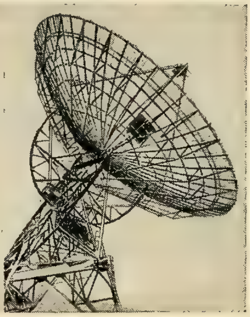


This Mariner II Spaceborne Data Conditioning System typifies Computer Control Company's ability to satisfy stringent size, power, reliability and delivery specifications for logic design, circuit, and module development, fabrication and packaging. The fast, real-time sampling, processing and control system gathered over 5 million bits of information from scientific instruments aboard the spacecraft and prepared data for transmission to Earth. In addition, it controlled: (1) the scan of instruments sweeping Venus' surface, (2) calibration operation checkout and (3) time sharing of scientific and engineering data in the telemetry system. Design to delivery: three months.

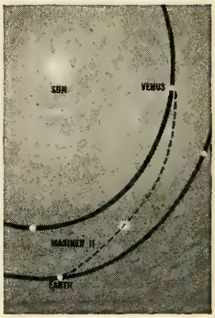
For future missions, 3C is developing a Space Data Automation System for Caltech's Jet Propulsion Laboratory under National Aeronautics and Space Administration contracts. This microelectronic system will provide sequences for optimum experiment yield. Circuit density on a volume basis will be about four times higher, using dot circuit components.

Coordinate Conversion Computer at Goldstone positions antennas tracking Mariner and other space vehicles

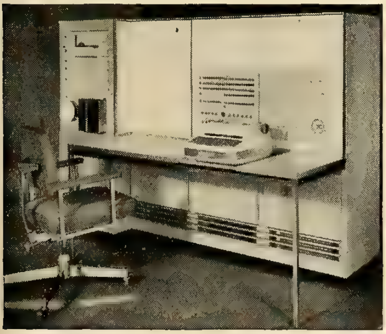




3C real-time Coordinate Conversion Computer at West Coast site continually positions 85-foot parabolic antennas to track orbiting satellites, as well as Mariner and other space probe vehicles. The antennas, computer and a microwave link form the closed loop system that tracked Mariner's 182-million mile journey through space. A similar system has been developed by 3C as part of an airborne tracking system designed to photograph missiles during re-entry.



OTHER 3C DIGITAL SPACE SUPPORT SYSTEM ACTIVITIES



Simulation of space vehicle conditions and associated instrumentation for spacecraft checkout requires high-speed data processing. The 3C DDP-24 computer is designed to solve complex engineering problems involving real-time digital control techniques, simulation, data acquisition and reduction. In tandem with the 3C Digital Resolver — dual arithmetic unit — the system provides on-line solution of algebraic and transcendental functions. The DDP-24 is particularly adaptable for real-time simulation in specialized hybrid digital-analog aerospace systems.

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For more information on 3C space systems, write for comprehensive Space Portfolio.

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On to Block II . . .

SA-5 Orbit Boosts U.S. Prowess

Launch puts 37,700 lbs. in orbit expected to last 1-12 months; officials gratified by S-IV stage performance; Johnson, NASA leaders see lead in capability; next shot to carry boilerplate

by Chris Butler

CAPE KENNEDY—The *Saturn I* program moved into its Block II phase with a resounding *SA-5* launch success on Jan. 29 putting 37,700 lbs. into low Earth orbit.

The orbiting package, described by some as a "flying junkpile," includes the S-IV second stage, the instrument unit, payload adapter, Jupiter nose cone and 11,500 lbs. of sand ballast.

SA-5 is the first of the new group of Block II vehicles, of which five more are to be flown. Unlike their Block I predecessors, all boosters in the new group will have powered second stages. Some will be used to launch unmanned models of the *Apollo* command and service modules.

In the Block II *Saturn I's,* the eight Rocketdyne H-1 engines will fly at rated thrust; propellant tanks have been extended to add 100,000 lbs. of usable propellant; and tail fins have been attached for stability.

Notable in last week's launch was the second straight success for the Pratt & Whitney RL-10 LOX-liquid hydrogen engines. Six of the engines gave the Douglas-built S-IV second stage total thrust of 90,000 lbs. Two of the same engines performed flawlessly on the *Centaur* launch vehicle last Nov. 27.

NASA officials said the launch appeared to give the United States the lead over Russia in the big booster field. President Johnson issued a statement declaring that the space agency had "just put into orbit the largest payload ever launched by any nation." However, the NASA figure for the payload weight included 14,300 lbs. for the spent S-IV stage. Russia has never released weight figures for the stages used to launch *Sputniks VII* and *VIII,* each of which was reported to have weighed 14,292 lbs.

● **Times 1,224**—Nevertheless, the scope of the *SA-5* feat can best be realized by the fact that the launch came only two days before the sixth anniversary of America's first space success Jan. 31, 1958, when the U.S. Army orbited the 30.8-lb. *Explorer I* satellite. *SA-5's* orbiting package weighs 1,224 times as much as *Explorer I.*

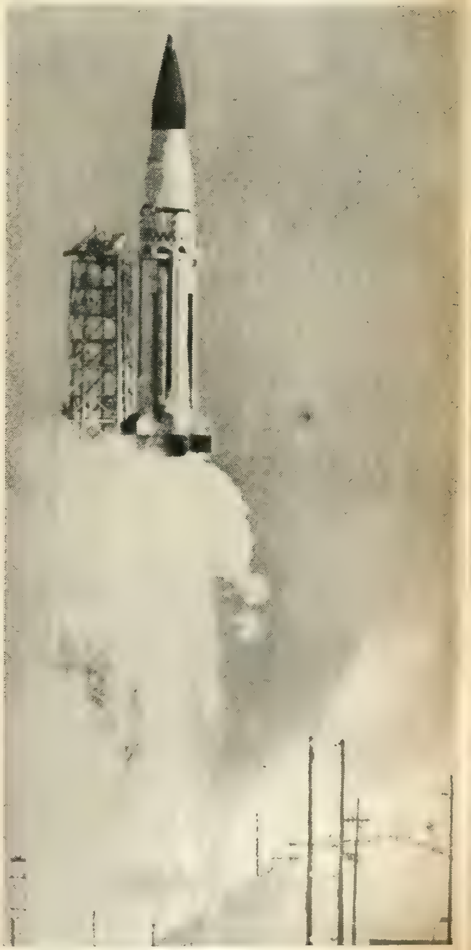
The two launches, six years apart, were closely related by the fact that many members of the *Saturn* launch team participated in the earlier space success and Bob Moser served as test conductor in both instances.

● **Holdups**—The *Saturn* launch was delayed several times by external factors, but only once by technical difficulties with the bird itself.

SA-5, due for launch in mid-December, was postponed for more than a month when cracks were discovered in metal sleeves linking segments of hydraulic and pneumatic lines. A total of 353 sleeves in critical areas were replaced.

A 48-hour delay developed Jan. 27 when an obstruction was found in the liquid oxygen replenisher line after the countdown had proceeded to within 100 minutes of launch. The first stage had taken on 93% of a full load of liquid oxygen when investigation revealed someone had forgotten to remove a "blind flange" from the line. This aluminum disk is used in making routine pressurization tests of line segments.

Additional delays were encountered on launch day when a ship at sea broad-



SATURN SA-5 begins triumphant flight from Cape Kennedy Jan. 25.

cast radio signals that interfered with the C-band radar, and a Department of Justice transmitter at West Palm Beach generated signals that caused concern about operation of the command destruct system.

After both sources of interference were eliminated, the *Saturn* was launched from Complex 37B at 11:25 a.m. EST, one hour and 25 minutes after the scheduled liftoff time.

- **Smooth trip**—The eight first-stage H-1 engines—operating for the first time at rated capacity of 188,000 lbs. each, for a total of 1,504,000 lbs.—performed perfectly. Inboard engines cut off on schedule at T plus 141 sec. and the outboard engines shut down six sec. later. The six RL-10A3 liquid hydrogen-liquid oxygen engines of the second stage ignited as planned at T plus 149 sec. and delivered a total of 90,000 lbs. of thrust.

The S-IV second stage, flying live for the first time, burned to T plus 629.4 sec. to achieve orbital speed at the time of insertion near Antigua at 11:35:32. A quick check of tracking data indicated the orbital parameters were: apogee, 467 statute mi.; perigee, 162; period, 94.8 min., and inclination, 31.4 degrees.

At 5:00 p.m., both apogee and perigee had increased slightly—to 471 and 164 mi., respectively. Inclination was then reported as 31.5 degrees. There was no change in period.

The package is expected to remain in orbit between one month and one year.

Shortly after the first stage burned out, eight on-board motion picture cameras in waterproof containers were ejected and impacted 720 mi. downrange, where pararescue men jumped to get them. Five packets were immediately located and retrieved. (See accompanying box.)

Two cameras photographed the interior of LOX tanks, four recorded retro- and ullage rocket firings, one monitored separation of the stages, and another viewed the effect of the solid oxygen-gaseous oxygen disposal system.

An on-board TV camera, which impacted with the first stage, provided real-time monitoring of separation and ignition of the S-IV stage engines.

In a post-launch press conference, Dr. Wernher von Braun, director of Marshall Space Flight Center, said a quick look at telemetry data indicated the ST-124 guidance unit, which rode open loop, had performed very well and probably will be used to guide *SA-6*.

The next *Saturn*, due for launch near the end of April from Complex 37B, will carry a boilerplate *Apollo* command module and conduct aerodynamic test of the spacecraft.

Von Braun added that two other *Saturns* are scheduled for launch before the end of this year and two more in the first six months of 1965.

- **"Ahead in capability"**—NASA's Associate Administrator Dr. Robert Seamans, asked whether the *SA-5* launch put the United States ahead in the space booster race with the Russians, said he did not look on it as a race, but "as a building program."

"There is little question that it took us ahead of the Russians in our capability," he added.

Seamans said the payload equivalent of *SA-5's* orbiting package was between 19,000 and 20,000 lbs. He noted that this would far exceed the 14,292 lbs. reported for *Sputniks VII* and *VIII*.

Von Braun estimated that Russian boosters used to date have a maximum thrust in the 700,000-900,000 lbs. range. He said he does not believe the Russians are using hydrogen as a fuel. However, he also said an apparent lull in Russian space launches by no means indicates that they have "run out of steam." ■

SA-5 Cameras Recovered in Cook Electric Capsules

EIGHT MOTION picture cameras aboard *Saturn SA-5* were protected by recoverable camera capsules developed and manufactured by Cook Electric Company's Tech-Center Division, Morton Grove, Ill.

The movie cameras and one television camera—the most elaborate optical instrumentation ever carried on a launch vehicle—went aloft on *SA-5*. The TV camera was not ejected, but all of the other units were separated from the first stage and impacted 720 mi. downrange. Pararescue personnel located and retrieved five of them immediately.

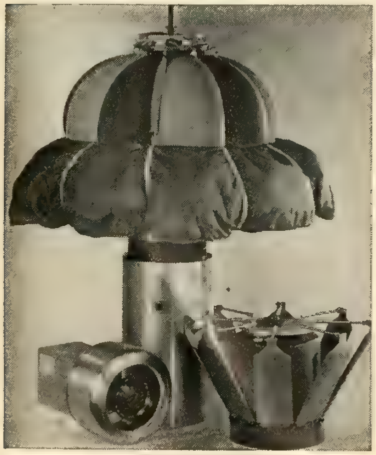
The movie cameras viewed the interior of two oxygen tanks by means of glass fiber bundles, and covered first-stage separation, retro-rocket firing, and S-IV stage ullage motor and propulsion system operation.

Ejected from *SA-5* at about 400,000-ft. altitude, the camera capsules reentered the atmosphere at about Mach 10.

Similar camera systems will be carried on *Saturn SA-6* and *SA-7*. Cook Electric has developed several other types of recoverable camera capsules, some of which were used earlier on *Atlas, Minuteman* and *Titan II* launches.

In the photo at left below, a camera capsule is shown prior to final assembly. It consists of an aluminum shell, a quartz window, the camera, re-entry equipment, and recovery aids.

At right below, a frogman tows in a capsule recovered during a series of test drops from aircraft by NASA's Marshall Space Flight Center. Capsule had come down with inflated paraloon.



LBJ lifts secrecy veil . . .

MIDAS Concept Showing Promise

Annual Presidential aeronautics and space activities report reveals AF space-borne system's launch-detection successes

by Heather M. David

MIDAS (Missile Defense Alarm System)—in some developmental difficulty about a year ago—now looks promising as a space-based warning system and, in fact, has already detected launches of U.S. test missiles.

The surprise disclosure by President Johnson in the annual Presidential report on aeronautics and space activities that "two flights were conducted on which a number of in-space detections were made of both liquid-fueled and solid-fueled ICBM launches from AMR and PMR" broke a long, security-laden silence on the infrared missile launch detection system.

The new advances in the sensor field that have brightened the *MIDAS* picture are in the general areas of sensitivity, processing electronics, cooling techniques for various detectors and miniaturization of detectors.

Although no breakthroughs in infrared detector technology have been made during the last year, general improvements in the existing design add up to a system that can detect lower-magnitude signals. This, plus redesign for a random, rather than circular, orbit apparently have greatly enhanced the satellite's usefulness.

The "non-existent program" was known to be in some difficulty as far back as July, 1962, in its inability to discriminate launches from other background signals. At that time, the Air Force was told to reorient the program toward a simpler design with an earlier flight-test goal. Department of Defense Research and Engineering chief Harold Brown told Congress in that year that half the $450 million spent on the system was wasted, presumably through the earlier, more complex approach.

● **Which satellites**—The two satellites, still not mentioned by name in the Presidential document, are believed to have been those launched by the Air Force from PMR with *Atlas-Agena B* boosters on May 9 and July 19, 1963.

Although all spacecraft details were classified secret by the Air Force—as have been all elements of the *MIDAS* system since May, 1961—satellite tracking data discloses that each of the above-mentioned launches consisted of a package of four satellites.

The May launch consisted of an unidentified payload satellite, accompanied by two TRS (tetrahedron radiation satellites), each weighing 1½ lbs., and the 50-lb. Project West Ford copper dipole communications experiment. All elements except the West Ford experiment are still in orbit at about 3,660-km apogee, 3,600-km perigee, with an inclination of 87.4° and period of 166.5 min.

The July launch was comprised of three secret satellites and one tetrahedron radiation satellite. These now orbit with an average apogee of 3,750 km, and perigee of 3,650 km, with an inclination of 88.4° and period of 167.5 min.

DOD officials indicated that the satellites have detected *Minuteman, Titan* and *Atlas* launches, both from AMR and PMR. Such possible sightings could have been made on May 13, when a *Titan II* was launched from Vandenberg AFB, and July 24—*Minuteman;* July 26—*Atlas D;* July 27—*Minuteman;* and July 30—*Atlas E* launches.

The *MIDAS* system originally was programmed to become operational in mid-1962, but apparently will rest in research and development for a while.

In spite of the apparent flight success, some doubts are still reflected in the President's message, which said in another place "There still remain unanswered questions regarding the technical feasibility, complexity, and cost-effectiveness of a spaceborne ballistic missile alarm system."

● **MIDAS record**—Out of what can be pieced together from unclassified sources, this is the tally for "Program 239A," as DOD calls it:

—Feb. 26, 1960, *MIDAS I*—4,500 lbs., failed to orbit when the second stage malfunctioned.

—May 24, 1960, *MIDAS II*—5,000 lbs., orbited successfully, but telemetry malfunctioned after second day.

—July 12, 1961—*MIDAS III*—3,500 lbs., first *Agena B* used to launch the spacecraft, and first launch from Pt. Arguello. It successfully orbited.

—Oct. 21, 1961—*MIDAS IV*—3,500 lbs., went into orbit. It also carried the first attempt at the West Ford experiment, in which dipoles ejected but failed to separate.

—April 9, 1962—No designation. In orbit.

● **Other secret satellites**—The report also revealed progress in the Air Force space technology satellite program, also classified as to launch dates and payloads in overall AF policy.

Exactly one-dozen experiments were carried on in the space environment, and some of them were recovered. These involved micrometeorite detection, cosmic radiation, ionization density, and galactic radio noise. During calendar year 1963, the Air Force recovered 20 "sensitive materials such as emulsions and metal transmutation samples" for radiation measurement.

The DOD section of the report said that although total payload capability was increased because of use of an improved booster, the capacity for scientific experiments was less than in previous years.

● **Other comments**—President Johnson disclosed that over 20% of the funds spent for all DDR&E programs are directed at space activities. Half of this, he said, actually goes to hardware, while the remainder goes to supporting technology.

The report indicated that more reliance will be placed on ground testing rather than that in space. "With the fundamentals increasingly well in hand, greater attention is being directed to putting space technology to work, and the balance of emphasis is shifting from the past need to explore to a growing competence to exploit," he added. ■

In House testimony . . .

McNamara Voices Some Optimism Over Nike-X, Tells Minuteman Plans

by Hal Taylor

SECRETARY OF DEFENSE Robert S. McNamara has declared that he believes the next several years may see solutions to the technical problems involved in developing at least a partial defense against a ballistic missile attack.

His optimism, he said, was based on the *Nike-Zeus* test program at Kwajalein Island, "which has met with considerable success," and on "preliminary studies of the *Nike-X* system."

As a result, *Nike-X* funding will be increased to $334 million in Fiscal Year 1965 and the *Nike-Zeus* program will receive an additional $40 million.

McNamara's statement was made as the House Armed Services Committee opened hearings on the Pentagon's FY '65 budget request. Other important comments on DOD's missile and space activities included:

—Planned changes in the *Minuteman* program—retrofitting *Minuteman I* silos with *Minuteman II's* in the first five wings—will place an additional cost of $500 million through 1969 on the U.S. strategic retaliation missile force, which the DOD secretary claims is more reliable and dependable than manned bombers.

—DOD has decided to postpone a military satellite communications system until it can be determined how well the planned U.S. ComSat Corp. can fulfill defense requirements.

—The 156-in. solid motor program will be continued, with funding of $12 million requested.

—About $10 million will be reprogrammed in FY '64 funds to get the Air Force's *Manned Orbiting Laboratory (MOL)* started. While the secretary did not say so, it is understood that an additional amount of slightly under $100 million will be spent on the program in the next fiscal year. At the same time, funding of Air Force participation in the NASA *Gemini* program is dropping from $13.6 to $6 million.

—A completely new surface-to-air fleet missile system will be developed, with $63 million available for R&D alone. It will include a new standardized missile to replace *Tartar* and *Terrier*. Funds are also requested for a new quick-reaction antisubmarine weapon to be installed in the Sea Hawk Destroyer. The weapon would have a considerably longer range than the present *ASROC*.

—The Navy has also decided to postpone retrofitting of the *Polaris A2* missile with the advanced *A3*. The delay in replacing the missiles in 13 *Polaris* submarines is expected to cost $425 million.

—The *Satellite Inspector* (*SAINT*) program—funded at only $2 million—has been completely reoriented in the past year. Current efforts in this area are being limited to development of necessary fundamental technologies for co-orbital interception and inspection. Some of the experiments planned for the *Gemini* program will support this effort.

- **Anti-missile defense**—In discussing the possibility of an anti-missile defense system, McNamara said an analysis of the *Nike-X* system completed to date provides some basis for belief that it can eventually satisfy three critical characteristics required of such a system. These include a high-acceleration missile, a Multifunction Array Radar (MAR), and components which could be sufficiently hardened to make direct attack on the system unprofitable.

He told the committee, however, that major problems must still be solved before enough data will be available to make a decision whether to produce and deploy the system.

He added that even if the problems are solved "we will still have to determine whether the potential effectiveness of the system would justify the very high cost of its deployment."

Defense experts estimate that a $16-billion *Nike-X* system would be relatively effective against small-to-moderate missile attacks. It would have to be considerably expanded, however, for defense against a large Soviet attack.

Even more importantly, the effectiveness of an anti-missile system in saving lives will depend to a large extent on the existence of a civil defense program. McNamara told the committee that until Congress makes a decision on the civil defense program before it, and the technical problems of anti-missile defense are solved, *"Nike-X* will continue as a high-priority research and development program without any commitment at this time to its ultimate production and deployment."

- **Strategic missile force**—McNamara said that the U.S. retaliatory force planned through FY '69 is more than adequate to survive a Russian attack and to retaliate with devastating effectiveness.

He said, however, that the rate of ICBM procurement—which tripled in FY '63 and doubled in FY '64—will increase at a slower rate during the 1965-1969 period. He also disclosed major changes in the *Minuteman* and *Polaris* missile systems.

Since the *Minuteman* force is increasing rapidly, the need for the slow-reacting and more vulnerable *Atlas* and *Titan I* missiles is declining. *Atlas D's* will be phased out in the next fiscal year and the *Atlas E's* and *Titan I's* sometime later.

DOD had planned last year a total program of 800 *Minuteman I's*, plus a large number of the improved *Minuteman II* missiles. The first 160 *Minuteman I's* were in place at the end of Fiscal 1963. By June of this year, DOD expects to have 600 in place and by June, 1965, 800. Funding for the first increment of 150 *Minuteman II's* was included in the FY'64 budget.

"With another year of experience behind us," McNamara said, "we are now proposing a major revision in the planned *Minuteman* force, a revision which we believe will greatly increase combat effectiveness, and which will cost about $500 million more through Fiscal 1969."

Minuteman I and *Minuteman II* squadrons will be integrated into a single system through the "internetting" of their communications and control systems, thus greatly enhancing the targeting flexibility of the force as a whole. This will be achieved both by retrofitting a large number of the *Minuteman I* silos in the first five wings with *Minuteman II*, and by co-locating additional *Minuteman II's* with these five wings.

While DOD plans only 50 *Titan II* silos in FY '65, it has tentatively programmed the funding of additional silos after that year. The actual number to be started will depend upon the situation prevailing a year or two years from now.

- **Polaris**—The *Polaris* forces are on nearly the same schedule as last year. The last six of the planned fleet of 41 submarines are fully funded in the Fiscal '64 budget. One major change, however, has been made in the program.

The first five *Polaris* submarines are equipped with the 1,200-n.-mi. *A-1* missile. The sixth through the eighteenth submarines will be equipped with the 1,500-n.-mi. *A-2* missiles, and the nineteenth through the forty-first with the 2,500-n. mi. *A-3*. Last year DOD had planned to equip all 41 submarines with the *A-3* missile and to begin this summer with replacement of the missile tubes of the first five submarines in order to accommodate the large missile. It still plans to replace the *A-1* missile with *A-3's*, but does not now believe that it will be necessary to replace the *A-2's* with *A-3's*, at least for a number of years. It believes that a force consisting of 28 submarines equipped with *A-3* missiles and 13 submarines equipped with *A-2* missiles should be able to handle effectively the targets assigned to the *Polaris* force. The Pentagon estimates that a total of about $425 million can be saved by postponing the *A-2* retrofit.

- **New strategic systems**—In addition to the *Minuteman II*, DOD is continuing an $8-million study and exploratory development program of an advanced ICBM which was initiated last year. It is also studying the possibility of work on improved propulsion, structures, and guidance for land-based missiles which will contribute to the improvement of existing missiles or the design of new advanced missiles.

The Pentagon has also included in the Fiscal '65 budget $5 million to examine the technical feasibility and military value of possible new advanced strategic aircraft which would serve as airborne missile platforms.

- **Space program**—McNamara said that while DOD has been pursuing a relatively wide range of efforts related to space technology, the time has come when these efforts "should be more sharply focused on those areas which hold greatest promise of military unity."

The immediate problem, he declared, is to develop a space vehicle to explore the contribution which man might make to military space operations. The Air Force *MOL* project, he told the committee, will fill the bill. It will be initiated with $10 million in reprogrammed FY '64 funds; additional funds have been included for the budget for the next fiscal year.

DOD will also continue its participation in the NASA *Gemini* program, both for the basic knowledge and experience to be gained and for the contribution it should be able to make to the *MOL* program. For this purpose, $1.4 million was reprogrammed in Fiscal '63 and an additional $13.6 million was reprogrammed in Fiscal '64. For FY '65, $6 million more is included.

Turning to the communication satellite system, he said DOD last year planned to develop a medium-altitude, random-orbit system that would be well within the demonstrated state of the art and could become operational at a relatively early date. This system would have involved 20 to 30 satellites randomly distributed in several orbits at approximately 6,000-n.-mi. altitudes.

"We intend to continue the Department of Defense medium-altitude communications satellite program in the research and development phase, but no operational capability will be initiated until we have had an opportunity to determine to what extent it is possible to integrate our plans with those of the Communications Satellite Corporation.

"The funds requested for Fiscal '65 would permit the completion of the R&D evaluation of system feasibility, i.e., the feasibility of the satellite communications systems as a whole and its compatibility wth the Defense Communications System."

The Pentagon will also continue the launching of nuclear detection satellites as part of Project *Vela* which will be funded at $61 million, $10 million more than in the current year. The *Satellite Inspector* program, for which $2 million is requested, has been completely reoriented. Current efforts in this area are limited to development of fundamental technologies for co-orbital interception and inspection.

Space funding for vehicle, engine and component development will pay primarily for the *Titan III* booster, which McNamara said has proven that it will pay for itself through a "lower cost per launch."

The 156-in. solid motor development program will continue with funding at $12 million.

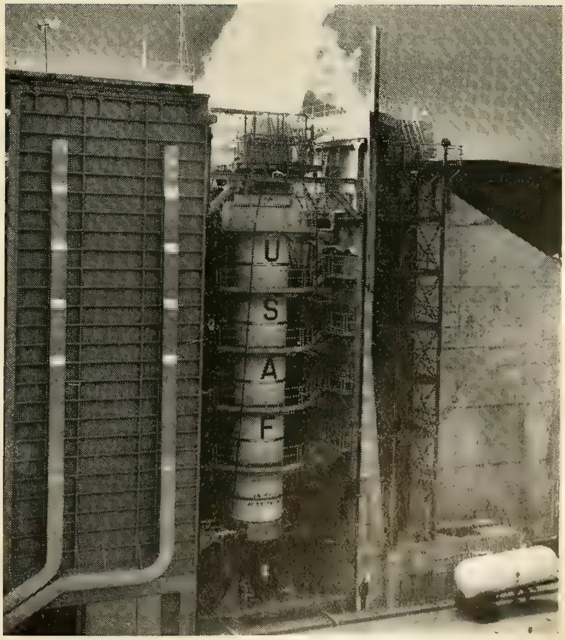
- **Research and engineering**—About one fourth of the $308 million requested for the Air Force's exploratory development program will be used for space or space-related subjects, including such broad fields as guidance, flight control, propulsion, life sciences, and electromagnetic techniques.

Advanced development projects for the Air Force include $8 million for the *X-15* program.

McNamara also said that while no decision has been made to procure or deploy the *MMRBM*, "I believe that we should proceed with its development as an insurance program to fill the gap between the *Pershing* and the ICBM's. The Joint Chiefs of Staffs are convinced that such a weapon system is needed." ■

New Success For 120-in.

SECOND successful static test firing of 120-in.-dia. solid motor for Titan III-C booster was conducted at United Technology Center test site in Coyote, Calif., Jan. 25. Yielding 1.15 million lbs. of thrust, the five-segment, 75-ft.-tall motor burned for 112.2 sec.



Optimists See Market Reaching Several Billions Over Next Six Years

Integrated circuits foreseen fulfilling 75% of all military circuit requirements by 1972; computers will be biggest microelectronics users; history of field traced back to 1946

BETWEEN $0.8 and 1 billion will be available to industry for microelectronics R&D and production over the next six years, according to industry estimates. This is a conservative figure. Many in industry predict a market totaling well over several billion dollars during this time.

Thirty-three percent of all current military circuits can be fulfilled by integrated circuits, according to Texas Instruments, Inc. By the '65 to '68 time period, the level will rise to 50% and to 75% by 1972. General Electric Co. generally concurs and suggests a further breakdown. By 1966, the company says, new military equipment will carry the following percentages of microelectronic circuits: computers (90%), data processing (75%), communications (85%), controls (55%), large (20%) and small radars (70%).

- **Extraordinary technical growth**—It is doubtful if anyone can determine a single point of origin for the field now called microelectronics. Its evolution naturally progressed out of urgent need from many directions, and has been based both on semiconductor and vacuum-tube technology.

Many believe, however, that the first public indication of things to come may have been presented by W. S. Hinman, Jr., and Cledo Brunetti in their paper "Radio Proximity Fuze Design," published by the National Bureau of Standards *Journal of Research*, Vol. 37, July, 1946. (Actual work on the proximity fuze began in August, 1940, under direction of the Office of Scientific Research and Development.)

In describing the development and design of the vacuum-tube radio fuze, the authors stressed the mechanical problems encountered in achieving "electrical stability in the presence of severe vibration."

Special Report on Microelectronics

IN THE FOLLOWING pages, MISSILES AND ROCKETS *Electronics Editors Charles D. LaFond, Michael Getler and Rex Pay present an overall view of the microelectronics field—its market potential, its sales problems, the manufacturers, and the state of the art in thin films, semiconductor integrated circuits and the pseudo and real hybrids. The report is presented in three parts: I. Market Summary; II. Manufacturers (p. 31); III. State of the Art (p. 50).*

MICROELECTRONIC computer logic circuit flat packages entering glass-sealing furnace. Now in full production, the circuits will soon become off-the-shelf items.

Thus, they reported, it was found that shock-mounted component assemblies had to be replaced by rigid mounting providing no relative motion. Then they stated: "Ideally, all parts should be made as a block so that the completed fuze would be literally as solid as a brick."

The Royal Radar Establishment in Malvern, England, investigated thin-film components in 1948 and as a result resistors were developed using a platinum-gold solution fired on a glass substrate. By 1950, these components were being produced commercially.

In a paper delivered in May, 1952, in Washington, G.W.A. Dummer of the R.R.E. predicted: "With the advent of the transistor and the work in semiconductors generally, it now seems possible to envisage electronic equipment in a solid block with no conecting wires. The block may consist of layers of insulating, conducting, rectifying and amplifying materials, the electrical functions being connected directly by cutting out areas of the various layers."

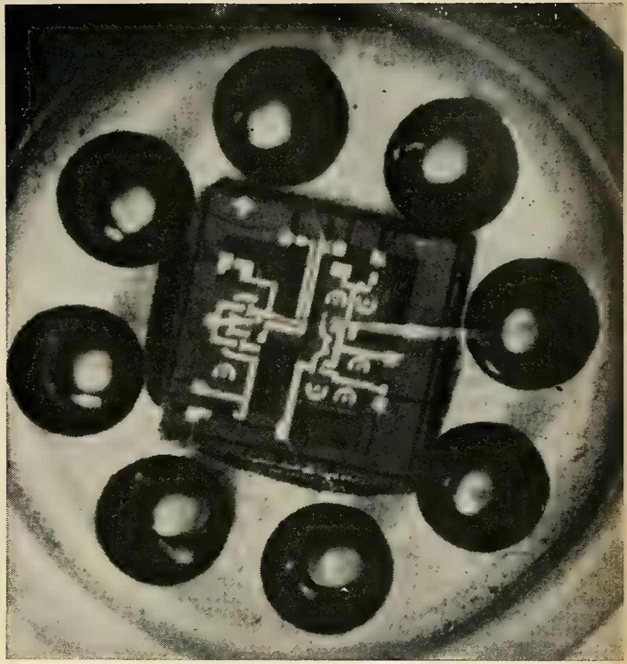
Under contract to the R.R.E., the Plessey Research Laboratories began work in 1957 to develop solid circuits.

From 1956-1957 on, the history of microminiaturization becomes muddled by claims of advancements throughout industry and government agencies, but at any rate, this appears to be the time during which a few sparks initiated a world-wide technological explosion. The number of participants grew exponentially, papers and even entire journals spewed forth showing the extent of concurrent R&D and by 1959-60, complex thin-film and semiconductor integrated circuits were being displayed and advocated with a vengeance.

The dust began to settle from this general upheaval by 1962, reason began to temper technical claims and the strength of early gamblers in the field began to show through in the form of contracts.

- **A real market grows**—No longer just a "great market potential," the microelectronics market—almost totally resulting from government funds and some manufacturers' willingness to match investments in R&D—had grown to between $15 and $18 million a year. The market then was almost entirely military. It still is, although the industrial market is beginning to open up in the computer and automatic control fields.

In 1961, Harry B. Parker of the Navy's Bureau of Weapons estimated that 40% of the receiving functions in military electronic equipment could make use of microelectronic technologies. By 1970, he said, the U.S. military requirement for dense circuitry would reach 64 million electronic functional units (active element groups) per year within just receiving equipment. At today's costs and based on the current state-of-the-art in production methods, this would represent more than $1 billion in equipment.



THIN-FILM microelectronic gate circuit produced by Electro-Optical Systems has four planar silicon transistors with tantalum resistors and capacitors. It is 120 mils square.

Similarly, he predicted, the same would be true for industrial equipment, thus providing a total military/industrial potential systems market of $2 billion a year by 1970.

A Missiles and Rockets summary of industry projections for total microelectronics sales (including funded R&D) for 1964 totals $60 to $70 million. Estimates of sales by 1970 vary from a conservative $200 to 225 million all the way up to $500 million a year. All estimates show a continuing rapid rise in sales, at least through 1972 and probably through 1975, before a significant leveling off occurs.

These estimates do not relate directly to unit sales growth since the unit cost of microelectronic circuits and subsystems is expected to drop sharply as production capability (and yield) are improved.

Government R&D funding for 1964 is broken down as follows: NASA, $3 million; Army, $5 million; Navy, $6-7 million; Air Force, $8-10 million. Total R&D estimates then are from $22-25 million; total circuit and prototype-equipment procurement is estimated at about $28-33 million. While circuit procurement dollars are expected to rise rapidly, R&D expenditures are expected to increase only slightly, leveling off at $30-32 million total by 1966-67.

- **A military market**—Military digital equipment now accounts for the largest portion of the microelectronic market. Systems currently scheduled to employ at least some advanced solid circuitry include *Improved Minuteman, Polaris A3, MMRBM, Titan III, Mauler, Sprint, Phoenix* and second-generation electronics in *Shrike* and *Typhon.*

However, the list of individual support systems now being designed with microelectronics is very large. Systems such as the Sperry-Rand computer being developed for the Navy's Tactical Data System, the Westinghouse Solomon computer, the new Navy airborne Loran C, the Fairchild single-axis flight-control system (Air Force), the Autonetics Monica-J computer.

The Navy, for example, has eight to 10 contracts out for prototype communications equipment all due for delivery within 18 to 24 months. Eight more are open for contract and will be due for delivery by July, 1965. This equipment is all composed of potentially high-production items.

The approach of each military branch, however, is markedly different. The Air Force has pressed research across the board, and has been the leader by far in the development of semiconductor integrated circuits.

The Navy has stressed developments in thin-film technology, although it is employing single-chip integrated circuits.

The Army, committed early to the Micromodule program using miniaturized discrete components, didn't really begin to seriously fund projects in this field until late 1960 and then with only a token effort. Now with its Micro-Circuit Module program and other contracts for integrated circuits, Army is beginning to expand its efforts, principally at Fort Monmouth, N.J.

Heart of the Air Force's microelectronics research effort is the Avionics Directorate, Aeronautical Systems Division, at Wright-Patterson AFB.

For the Navy, it is the Avionics Division of the Bureau of Naval Weapons, Washington, D.C. Also, BuWeps has other major supporting facilities: the Naval Air Development Center, Johnsville, Pa.; the Naval Avionics Facility, Indianapolis, Ind.; and the Johns Hopkins University Applied Physics Laboratory, Baltimore. (NAFI has currently under development more than 50 different thin-film circuits.)

The Army's microelectronics effort is centered at the Electronics R&D Command, Fort Monmouth, and the Army Missile Command at Huntsville, Ala. Also, the Harry Diamond Laboratories in Washington maintains a modest effort although it is highly specialized (fusing and arming devices).

• **NASA cautious**—The total NASA effort today in microelectronics probably does not exceed $3 million in outside contracts. About $1.8 million of this is for R&D. The remainder is out of project funds for vehicle programs such as *Saturn*, *Apollo* and the *Interplanetary Monitor Probe (IMP)* series. The *Apollo* guidance computer circuits will probably create the largest single need for microelectronics for several years to come in NASA systems.

NASA's Electronics and Control Division, Office of Advanced Research and Technology, funded a small research effort in microelectronics for about three years through the Harry Diamond Laboratories (Army). A $300,000-a-year program, chief industry participants were General Electric and Philco.

Headquarters, said Dr. Albert J. Kelly, director of the Electronics Division, will spend about $200,000 this year on several small study projects. Study contracts to be awarded during the next several months will be for interconnections, physics (and modes) of failure, thin-film active devices and radiation effects on circuits.

A small nine-month contract, said Kelly, is being performed by Arthur D. Little to determine the extent that the telemetry and command subsystems in five existing satellites could have used advanced microelectronics. These include *Syncom*, *Nimbus*, *OAO*, *OGO* and *IMP*.

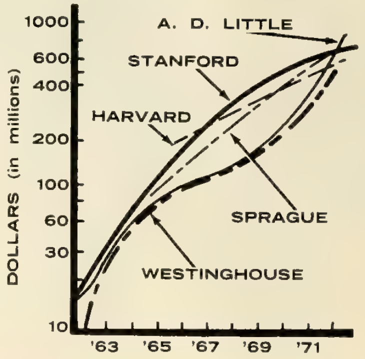
Langley Research Center is active in low-power device development and is building an in-house capability for producing screened circuits. The center is expected to avoid crystalline structures and concentrate on a thin-film approach to the fabrication of active elements. Langley's R&D expenditures to industry will be about $700,000 this year.

Marshall Space Flight Center will spend about $700-800 thousand this year for microelectronics R&D and for *Saturn* circuits.

The *Saturn* project involves direct exchange of three electronic subsystems, currently using discrete components, with advanced microcircuitry. This will be a two-year effort, running about $300,000 per year.

Another effort being stressed by Marshall is an attempt to solve the interconnection problem.

Jet Propulsion Laboratory and Goddard Space Flight Center are each building a small in-house capability and will account for $300 and 200 thousand, respectively, in a variety of small contracts for specific circuit, subsystem, and technique development.



Typical Total Industry Projections for Microelectronics

The bulk of Goddard's effort is in-house. Its chief effort is development and testing of a series of digital subsystems. The *IMP* series will serve as a test vehicle. Three *IMP's* will provide a good evaluation for an optical aspect computer employing Texas Instruments' SN510 and SN514 solid circuits. The first of these *(Explorer XVIII)*, launched Nov. 27, 1963, is still operating without problems.

IMP-2 and *-3* may carry a similarly microminiaturized telemetry encoder; *IMP-4* and *-5* will carry a highly advanced digital oscillator for a 64-channel PFM telemetry system. Circuitry will be all microelectronic in the digital logic sections. *IMP-6* and *-7* will make extensive use of such circuitry if the earlier subsystems exhibit satisfactory performance.

Goddard's Dr. R. W. Rochelle, chief of Flight Data Systems branch, disclosed that for scientific satellites, particularly, the principal problem is in reducing the power requirements of currently available integrated circuits. To that end, Westinghouse has a small Goddard contract to develop a symmetrical complementary NPN-PNP flip-flop with a power drain of about 0.3 milliwatt. (Those currently available require at least 3 mw.)

Other problems, said Rochelle, include radiation susceptability and thermal problems resulting from increased circuit density.

Goddard is looking for any new advanced circuits that will permit design of more complex computers and still meet the limited power requirements. A new device that the center will probably test is a diode matrix (16 x 16) developed by Motorola. The single tiny hybrid carries 256 diodes and 16 resistors.

The center now has a microcircuit facility under construction. Designed to be a state-of-the-art laboratory, it will have both a thin-film and an integrated circuit capability and will permit emergency production of specific circuits when needed. The facility is expected to be able to produce circuits by April 1.

• **View from the top**—As indicated in more detail later in this report (Part II), five U.S. manufacturers lead the field today in production capability and in contracts. They are Motorola, Inc., Texas Instruments, Inc., Fairchild Semiconductor, Westinghouse Electric Corp., and Signetics.

Westinghouse is the second source with Texas Instruments for producing 17 *Improved Minuteman* computer circuits. It is also producing circuits for the guidance computers in *MMRBM*, *Titan III* and *Apollo*.

Westinghouse is still going through the pains of building an expanded new facility near Baltimore to house its many projects previously scattered about the country. Its *Minuteman* integrated circuits, however, are being produced primarily at a twin facility on the West Coast.

Total production has not been revealed by the company, but officials did disclose that the new Baltimore plant will continue to grow rapidly from the present 15,000 units per month.

Texas Instruments, an integrated circuit supplier since mid-1960, is producing between 30,000 and 50,000 integrated circuit devices per week. A major part of this output is being produced on a three-shift-a-day basis just to meet *Improved Minuteman* commitments.

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"SEE US AT IEE . . . BOOTH 1915"

Other major TI circuits are being supplied for Litton's TFX (Navy) computer and Sperry-Rand's Loran C (Navy) receiver.

In 1963, TI integrated circuit sales are estimated to have been between $9 and $12 million and the firm expects to triple its volume in 1964.

Motorola lays claim to having made the largest investment of anyone in U.S. industry in its integrated-circuits facility. Its pilot production line is believed to be larger than any other firm's production line except that of TI.

In the past five months, Motorola has won all the major IC contracts: Autonetics Monica-J computer, Litton's TFX computer and the possibility of up to an $11-million order from Westinghouse for Solomon computer circuits if the Air Force orders the system. The firm is also supplying circuits to Sperry-Rand for the Naval Tactical Data Systems.

Fairchild Semiconductor is now working a standard three-shift day and claims a production rate of from 30,000 to 40,000 integrated circuits per week. Before becoming a division of Fairchild Camera and Instrument Co., the firm was one of the pioneers in the microelectronics field.

Fairchild's two principal contracts are for computer circuits for the *Phoenix* missile and *Apollo*.

Signetics, smallest of the big five, has made its way through a variety of relatively small contracts. A subsidiary of Corning Glass, it no doubt has been supported heavily in R&D by the parent company.

Among its diverse contracts, Signetics is supplying integrated circuits for *MMRBM*, FLIP and has hopes of obtaining orders for the TFX and *Apollo* computers. Another major effort is the development of a family of 10-mc integrated circuits for the Army Electronics Command at Ft. Monmouth.

- **State of the market**—One of the intriguing ironies of microelectronics, as a Bell Labs scientist points out, is that the transistor, the development of which triggered such intense activity in the manufacture and use of new miniaturized electronic systems, is now one of the bottlenecks to achieving the next major level of size reduction.

It is to this and other questions of design approach, process control, and materials research that the US electronics industry is now addressing itself in a widespread effort to realize the vast potential and enormous pay-offs in cost and performance predicted with the use of integrated circuits.

It is this promised growth, which has come faster than predictions only a year old foresaw, that is responsible for the tenacity of a large part of the marginal suppliers of electronics components and circuits. Although there has been much concern about the failures in the semiconductor business, the number of firms that actually have withdrawn are few, with the shakeout resulting more often than not in mergers and reduced product lines.

The fate of the components manufacturer is still in the balance. There no doubt will be a coming together of component and systems-type firms, with systems companies moving more and more either to buy up or arrange some kind of tie-in with a components outfit possessing the equipment and semiconductor-based technology.

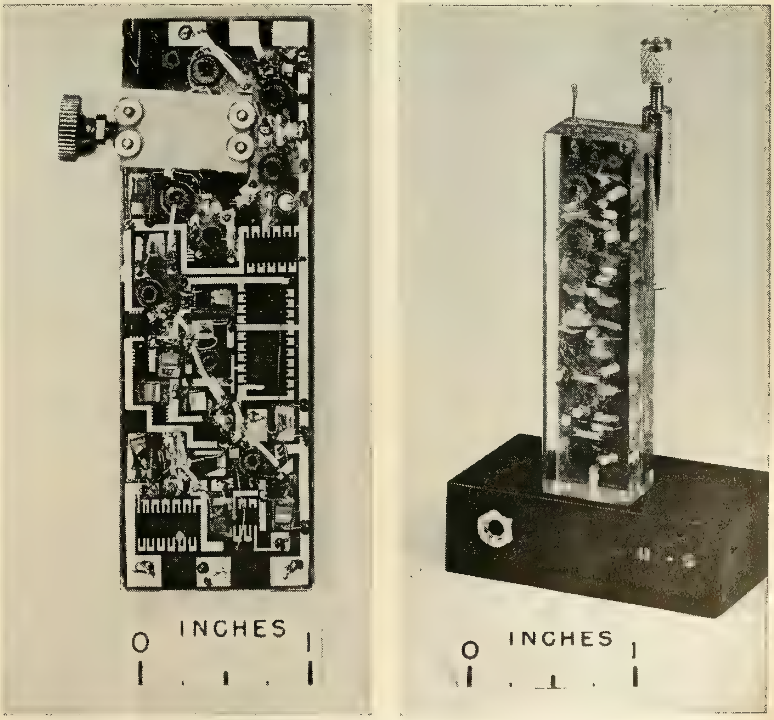
For a systems firm to move heavily into the market or for a new firm to form solely for manufacturing IC's, the cost is estimated from a few million up to $15 million over the first 2-3 years (depending on the technical base), with no likelihood of fast equipment write-off such as occurred in the early days of the transistor industry. It is more likely that components firms will be taken in by systems firms than the other way around; primarily because it is more difficult for a components firm to buy a systems capability.

- **R&D costs high**—To stay current in the technology one top executive estimates it now takes $2-5 million a year in R&D (or about 10-15% of sales). This means that firms with under $20-30 million in total sales will find it difficult to survive. The same figures may hold true for systems companies with equipment sales under $100 million that make a bid to develop their in-house manufacture. Critics say that the investment in equipment and continuing R&D may very well not add up to the contributed value of IC's. "If you don't spend for the R&D you need, the answers you get from a smaller expenditure may indeed be distorted opinions of the technology," explains Westinghouse's Harry Knowles.

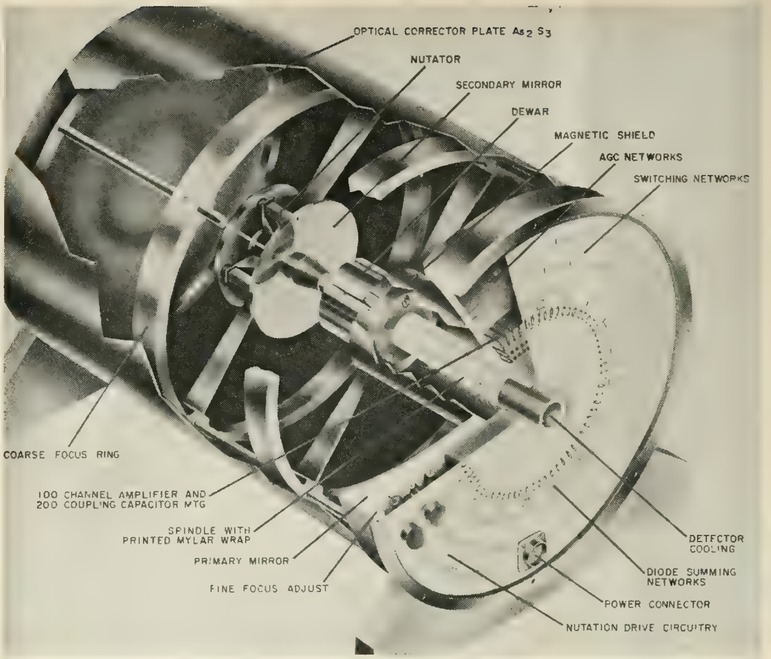
- **In-house capability**—The in-house lab and production facility continues to spring up in more systems companies despite the admitted high cost of equipment, R&D, and the existence of a technically well-grounded industry.

Nevertheless, with equipment manufacturers faced with the fact that microcircuits for aerospace applications in particular rapidly will become a very large part of the contributed dollar value of their equipment, the desire to learn the technology and to launch in-house production operations is very powerful.

Some firms already have made this decision (see Part II). Whether many systems companies decide to manufacture at least some circuits in-house,



BOTH SYSTEMS above are 10-20 mc AM receivers developed by Harry Diamond Labs, and using two-gang tuning capacitors. Potted unit (right) uses miniaturized discrete components, includes power supply. Unit at left does not include a power supply.



ALL ELECTRONICS in this infrared detecting and tracking system use integrated circuits. Westinghouse device's IC mosiacs consist of 10 x 10 detector-cell patterns on individual wafers.

virtually all want the capability to design and produce enough devices to evaluate them and relate exactly what they want to their suppliers.

It is not yet clear how many equipment makers have the in-house demands to make manufacturing operation economical. Some observers doubt if at the present time many in the U.S., outside of IBM, Western Electric and a handful of others, could economically justify building most of their own circuits.

- **Diversity vs. standardization**—One of the hallmarks of the burgeoning microelectronics business in the U.S. is diversity. Differences in approach run rampant throughout an industry while visions of standardization dance in the heads of many of the customer agencies and some of the manufacturers.

One of the reasons for the diversity lies in the very nature of microcircuitry—namely that the ability to form these circuits with so much design latitude seems to argue more for standardization of processing than standardization of circuit design.

While some argue that standardization will stifle innovation, others disagree, claiming that if standardization comes it will likely arrive in stages with no crippling effect on introduction of new methods. With no standardization, single source procurement will become increasingly hazardous for the buyer.

- **Research needs**—If microcircuitry is ever to realize what its proponents say is within its grasp, research must certainly be as much a part of its makeup as basic engineering.

While semiconductor technology remains the IC cornerstone, more physicists and chemists are being added to staffs as the problems of materials and process control become the key to the economies proponents hope to find in new IC, thin-film and hybrid microcircuitry.

"Research with good odds" is described as the approach at RCA's Sarnoff Laboratories. "We look for areas in which we stand to improve things from one to 10 times with about a one in 10 chance of success with enormous payoffs."

The manner in which Government is supporting research is also debated within industry. Some say it is inefficient, tieing up too many people on Government-channeled projects. Once funding stops, research stops.

What is needed, critics say, is more government support in broad areas. Many agree there is great need of support in research aimed at new quality control and reliability data, particularly in thin-film and hybrid circuitry.

- **Sales problems**—Introduction of microcircuitry into a company's brochure has also introduced sales problems. For one, the need for a highly technical sales staff has never been more apparent.

Purchasing departments are facing the same challenge. Not only do buyers and sellers now have to know their own product, but they must be knowledgable of a host of system design problems and material interfaces.

For IC manufacturers also branching into systems companies, and for the reverse situation, the idea of disclosing proprietary designs is becoming increasingly sensitive among firms with similar sales interests. One executive also points out his firm's particular reluctance to have as a supplier a manufacturer who also is under heavy volume delivery pressure by another in-house division. "If a batch goes bad, who gets cut out?" he asks.

Major suppliers of IC's for the two largest missile/space users programs to date—Improved *Minuteman* (Primarily Texas Instruments and Westinghouse) and the *Apollo* guidance computer (primarily Fairchild, with Raytheon and Westinghouse)—stand to add other long term benefits from their association with these programs other than the already invaluable immersion in turning out volume quantities of IC's.

Missile/space use of IC's is probably the one area where cost may not be the predominant criterion for basing production decisions, with premiums paid for improved reliability and very high performance custom efforts.

However, there is no question that the manufacturing cost associated with particular circuit approaches will be the predominant factor in virtually all other applications, and that this fact is certain to have at least an influence on much of the aerospace market. Circuit prices today range between about $12-50 per circuit.

Whether manufacturers' warnings of the high costs involved in equipment, R&D and production are being heeded by others now facing the decision to enter will be seen within the next year or two.

Thus, for a firm to make the decision to make or buy its IC's in the future, it must consider the following: the existence of an already developed IC manufacturing industry, heavily based in semiconductor technology and exploring the advanced hybrid and thin-film techniques, that says it can supply IC's for less than what it would cost an individual firm to embark on its own production; the admitted high cost (no matter whose figures are used) of equipment and continuing R&D; the extent of the contributed dollar value that IC's will comprise of the total cost of equipment the company builds; the ability of sales to support R&D; and the degree to which it must have this capability to protect its systems business.

Such deliberation creates questions not easily answered. ■

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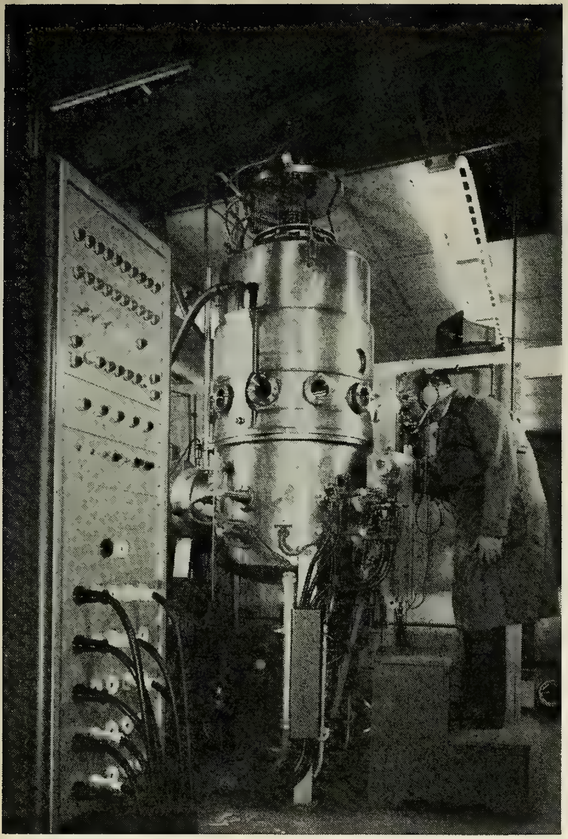

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Five Firms Top Burgeoning Field

Intensive R&D, expansion of facilities, desire to refine technical competence typify leading manufacturers; a survey of trends demonstrated by 34 companies

THE TOP FIVE manufacturers in the world today in the production of semiconductor integrated circuits (IC) are Fairchild Semiconductor Div. of Fairchild Camera and Instrument Co.; the Semiconductor Products Div. of Motorola, Inc.; Signetics Corp., a subsidiary of Corning Glass Works; the Semiconductor Components Div. of Texas Instruments, Inc.; and the Molecular Electronics Div. of Westinghouse Electric Corp.

Each maintains a broad and intensive R&D program, each is pressing to expand its facilities and strengthen its technical competence. All are operating at a fairly heavy financial loss, and none expects its integrated circuit sales to register on the black side of the ledger until the 1965-66 period.

Moreover, at least as far as external sales are concerned, each of these five manufacturers shows every sign of staying at the top of the market for many years to come.

Radio Corporation of America, General Electric and Sylvania Electric are rising rapidly. Philco and Bendix are limiting their lines initially, but are aiming for a high production capability. Autonetics, Litton and Hughes are heavy users now of integrated circuits and are expanding their in-house capabilities.

International Business Machines is expected to become a very large producer for its own systems use and Western Electric appears to be taking a very conservative approach, but will probably be a large producer for internal use in its commercial equipments.

For reader convenience, activities of the top five manufacturers are presented below, followed by many of the other firms, both large and small, now engaged in the burgeoning field of microelectronics.

Fairchild

Fairchild Semiconductor, Mountain View, Calif., is one of the old timers among the IC producers. The original DCTL "Micrologic" gates have now been replaced by a series of nine epitaxial RTL devices, with typical propagation delays of 11 nanoseconds. Fairchild notes that these promise to be more reliable and five times more radiation resistant than the non-epitaxial devices.

Fairchild is supplying IC's for the *Apollo* and *Phoenix* programs and claims to be producing 30,000-40,000 IC's per week. The main facility is about 45,000 sq. ft. in area and the assembly area of this is likely to be doubled within the next six months, when some transistor assembly is moved out.

A new line of Milliwatt logic circuits has been announced. Achievement of low power operation has resulted from new concepts of geometry rather than further size reduction.

The company also is producing a new flat package for its devices, which uses a ceramic top and bottom and a glass seal. Although Fairchild agrees that the flat pack is the way to go—ultimately to a completely solid pack of the GE flip-pack type—the company feels that at present there is not enough data on flat-pack reliability. Fairchild points out that no reports have come to them about leads falling off their TO-5 or TO-47 cans. The disadvantage of absence of regular geometry in the can-type of encapsulation may be overcome soon with the development of a new lead geometry that facilitates auto assembly.

Fairchild's flat-pack is an all-aluminum system, but other metal combinations less susceptible to damage are being studied.

Fairchild has the capability of putting 15 transistors and 22 resistors in a single chip and suggests that at this level of complexity the problem of packaging calls for very careful attention. The company is not sure whether the next step will be development of subsystems in a single wafer or the redesign of the package.

One approach Fairchild is studying is cellular logic, where connections are made only between adjacent cells. The company is looking at all areas in computer technology, including memories, as possible applications for IC techniques. One possibility being studied is use of IC's in associative memories.

Fairchild is developing IC complementary transistors as logic gates, and also insulated-gate field-effect transistors. The latter look very promising in IC's from theoretical considerations, the firm reports, but are proving difficult to integrate on a production basis —due to the incompatibility between the techniques for making the devices and the techniques of integration.

Complementary transistors also look highly useful in IC's; the difficulty is in fabricating a good PNP and a good NPN in the same chip.

Motorola, Inc.

Motorola Semiconductor Products Div.'s main product line in Phoenix is a series of current-mode logic circuits with an average propagation delay of 6 nanoseconds and a power dissipation of 35 mw. The division also produces thin-film passive devices and multiple-chip circuits in TO-5 cans. Use is also made of the techniques of depositing thin-film components on diffused IC's.

The company offers IC's in a TO-5 can and also in a ceramic flat pack. Motorola believes there are very strong advantages in the all-aluminum interconnection system they have developed for the flat pack.

The company is pursuing an aggressive pricing policy in IC's and is rumored to have secured the Monica contract from Autonetics for an all-time low price of $12 per circuit. At the same time, the IC department does not expect to make a profit until 1965.

Their diffusion facility in the main IC line contains 48 Hevi-Duty furnaces with a 24-in. flat zone controlled to ± ½°C. A recent addition to their assembly area is a high-speed automatic indexing probe for go/no-go testing of devices on slices. Overall yield on the IC line is claimed to be over 10%, and as high as 50% for some circuits. Automatic equipment is also used for final testing of the devices. About 51 tests are carried out on T^2L logic in less than a second, using a punched-tape-programmed tester.

The production line is handling 60-70 different circuits per week. Up to 40,000 good circuits per week can be produced on the present line (20,000 sq. ft.)

For Monica, Motorola holds a $300,000 initial contract from Autonetics. They will produce all 18 circuit types and are responsible for the entire supply. Motorola also expects to receive a contract from Litton for TFX circuits. The company says it is involved in about 90% of the major IC programs.

Motorola says it is producing every type of integrated digital device: highly-modified T^2L, slightly-modified T^2L, DCTL, four types of DTL. One of the last is a family of circuits used in the Univac computer (contains 20,000 devices).

Signetics

Signetics Corp., Sunnyvale, Calif., has probably penetrated the IC market to a greater extent than any of the other "small" manufacturers. A subsidiary of Corning Glass, Signetics has a $159,000 Army contract to develop a family of 10-mc IC's. It has produced a TFX gate for evaluation by Litton and has developed a differential sense amplifier for *Apollo*. It is supplying circuits to Nortronics for *MMRBM*, floating intertial platform (FLIP) guidance and a digital computer.

The circuits being developed for the Army are similar to the present standard Signetics DTL line but two to three times faster. Shipment of these epitaxial devices is likely to be complete by the end of this month.

Signetics offers "Verifeb" devices, which are IC's that are complete except for deposition of aluminum interconnections. In this way, something of a custom approach is achieved at a cost comparable to standard circuits.

In the standard line, Signetics uses DTL logic. Stage delays of 8 to 10 nanoseconds can be achieved with this form of circuit. For shorter delays tunnel diodes might be used in about 18 months time in IC's, but the present interconnection problem tends to negate the advantages of high speed.

Signetics recently announced a new isolation technique that makes IC components behave like discrete components. The company plans to begin construction this month on a $5 million, 250,000-sq.-ft. building complex.

Breakdown voltage between devices can reach 1,000v and parasitic capacitance can be cut by an order of magnitude or more, they claim. The technique does not consist of epitaxial deposition on an insulating substrate. It will lead to the development of low-power and high-frequency IC's, they report, and make possible complex junction structures (more than four layers) that were hitherto unattainable. The technique does not improve the present wide tolerances in resistor values.

Signetics is also working on deposited thin-film resistors on top of active silicon substrates, and claims to have achieved high sheet resistivity with good temperature stability. Several megohms of resistance is achieved in very thin films, and the company expects to announce devices using this technique early this year, after obtaining results of life tests. The material used has not been disclosed.

Other lines of research at Signetics are the development of high-current devices, high-voltage devices, field-effect transistors, and PNP-NPN devices. Field-effect transistors need further development of compatability of two types of production processes. PNP-NPN processing is improving and will be applicable soon. Zener diodes have been integrated in experimental circuits.

Signetics is working on use of a thin layer of glass as an encapsulant for IC's. Currently Signetics is using a glass package, which it will make available for licensing to other companies. A ¼-in. square has been selected as the basis for the package, to give greater mechanical strength and conformity to the shape of the majority of IC chips. This also gives a uniformly wide shoulder of optimum mass and surface area around the chip, to ensure that the seal around the leads and the encapsulation seal are hermetic. Materials used are hard glass and gold-plated Kovar. Sealing can be achieved in a conventional nitrogen-atmosphere dry box, without large, specially designed ovens.

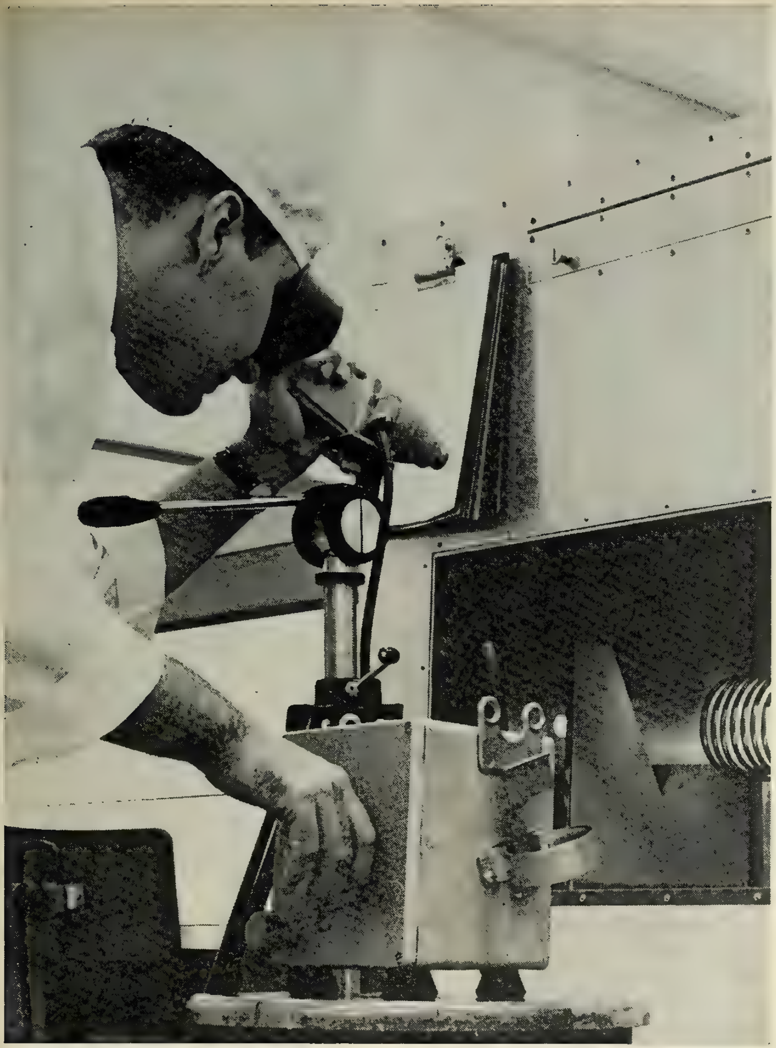
Signetics also is working on a flip-chip package of the type publicized by GE. At present it is using thin-film aluminum films for interconnections between devices, although other conductive films and conductive regions within the silicon substrate have been used.

Texas Instruments

Texas Instruments' Semiconductor Components Div. in Dallas has been supplying IC's since mid-1960. Recently the Series 53 circuits, including the equivalent of 61-69 components, has been announced as a faster, smaller successor to the 51 Series. Currently a large part of TI's production is going to North American Autonetics for use in the *Minuteman B* computer. Working three full shifts a day, TI's IC line is probably producing between 30,000 and 50,000 devices per week.

Other projects that TI is supplying circuits for are the Litton TFX computer and Sperry's Loran C receiver.

TI offers three main IC types: cat-



CALIBRATED optical pyrometer being used to take temperature profile during an epitaxial growth operation at Westinghouse Molecular Electronics Div., Elkridge, Md.

alog lines, the master slice, and custom design. Most large orders are custom. Master slice devices consist of diffused active and passive devices on which a customer's own interconnection pattern is superimposed, giving partially custom design.

In 1963, sales of IC's amounted to $9-12 million. TI expects that this will at least triple in 1964. At present, TI says 33% of current military circuits can be fulfilled by IC's, and IC's are competitive in price with discrete components.

In research, TI is looking at light emission as a means of interstage coupling and is investigating various types of surface processing. TI would like a higher temperature material than aluminum for deposited interconnections. Deposited metal alloy resistors on top of active silicon devices have been produced in TI labs experimentally, but are not used in production. In packaging, TI has looked at the problem of circuits that need 50 or more leads and thinks that the flat package will remain suitable.

Main problems in general with flat packs have been leads falling off and loss of hermeticity.

TI markets a number of devices for improving user's ability to handle IC's, including an automatic circuit tester and a dynamically controlled parallel-gap welding machine. The feature of the welder is that it holds a constant voltage drop across the weld, making the welder independent of material thickness and cutting down the incidence of faulty welds.

Westinghouse Electric

Continued exploitation of the potential of the monolithic silicon epitaxial integrated circuit, a technology that Westinghouse's C. Harry Knowles, general manager of the firm's Molecular Electronics Div., says "scientists haven't even come close to fully exploring," will continue to dominate microcircuitry development at Westinghouse, certainly for the immediate future.

"Designers, too, will take a long time digesting nanosecond switching capabilities," which Knowles sees as possible within the realm of monolithic IC technology.

WEC, generally ranked among the top four or five suppliers of IC's to the nation's markets, has done well with the IC approach thus far, and Knowles shows no inclination to "leave the one we've got."

"People ready to rush on to something new," Knowles told M/R, "ought to stop and take a good look at what an elegant thing a P-N junction is. When you haven't faced the problems of meeting the customers' volume and deadline requirements, it's easy to wax eloquent." Knowles reports that his division shipped about 15,000 IC's in January, "and the simplest thing we make is a 3-input NOR gate." In August '63, the firm was delivering about 1,000 circuits a month.

What Westinghouse currently calls molecular electronics is in fact what most of the industry calls monolithic silicon integrated circuits. The semantics problem results from an Air Force program begun at WEC in 1959, which has as its goal the pure meaning of molecular electronics—that being the performance of complete circuit and systems functions within a single piece of solid-state material in which all operations are carried out on a molecular level without the use of separately identifiable components. Enroute to, and related to, that goal is IC technology.

The Air Force program is set up on a cost-sharing basis with a total of about $1-5 million put into it each year.

Westinghouse IC production facilities are in two plants, the new division outside Baltimore, set up 18 months ago and recently quartered in new facilities, and a West Coast plant in Newbury Park, Calif. The latter is primarily concerned with the WEC contribution to the *Minuteman* program.

WEC and Texas Instruments now hold contracts covering the largest portions of the *Minuteman* circuit types, about 17 between them.

In addition to the *Minuteman DTL* logic circuits, WEC also reportedly shipped "tens of thousands" of DCTL NOR-gates packaged in TO-47 cans for use in Raytheon's *Apollo* guidance computer. The firm is also supplying 12 different SIC circuits types to Univac Div. of Sperry Rand for use in the

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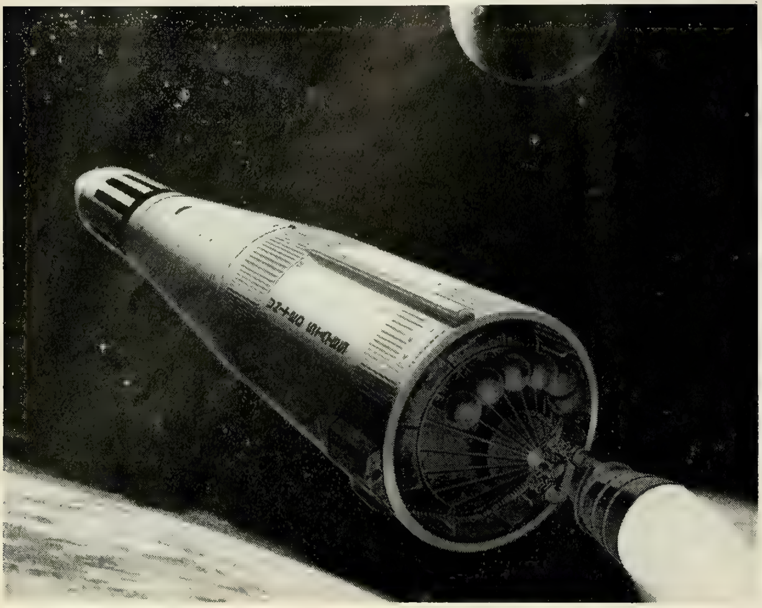
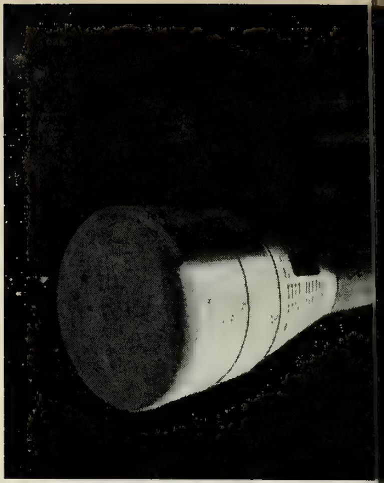


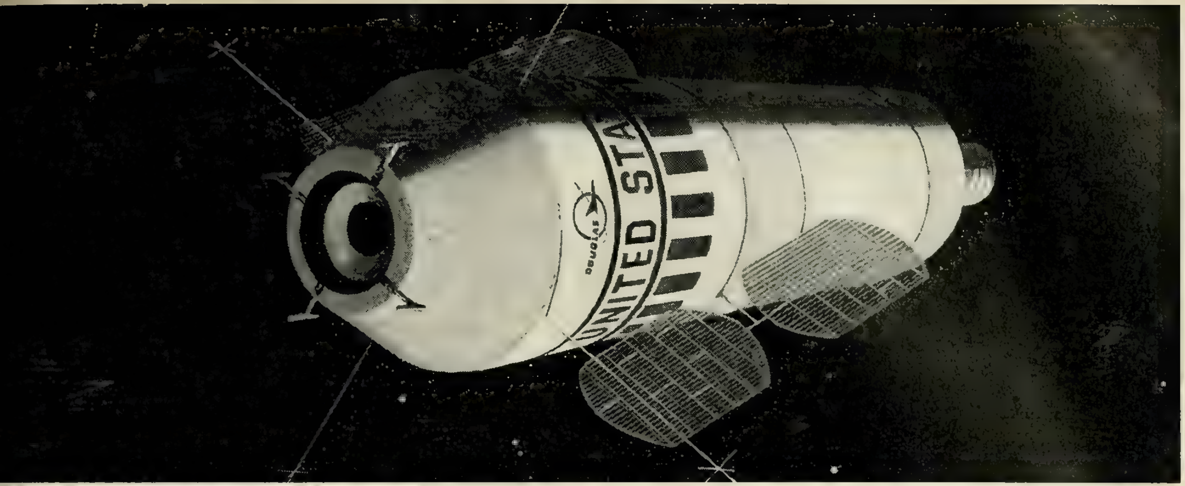
TO HELP PUT MAN ON THE MOON, *Saturn* S-IVB is being built by Douglas under direction of NASA's Marshall Space Flight Center. S-IVB is 58 feet tall and 22 feet in diameter. As upper stage of *Saturn*, it will provide the thrust that will send 3 *Apollo* astronauts from earth orbit to moon orbit.

PACKAGING THE EARTH'S ENVIRONMENT for delivery anywhere in the solar system is the aim of Douglas biotechnology research. Means are being developed to provide spacemen with every factor they require to allow them to survive and perform efficiently during protracted space missions.

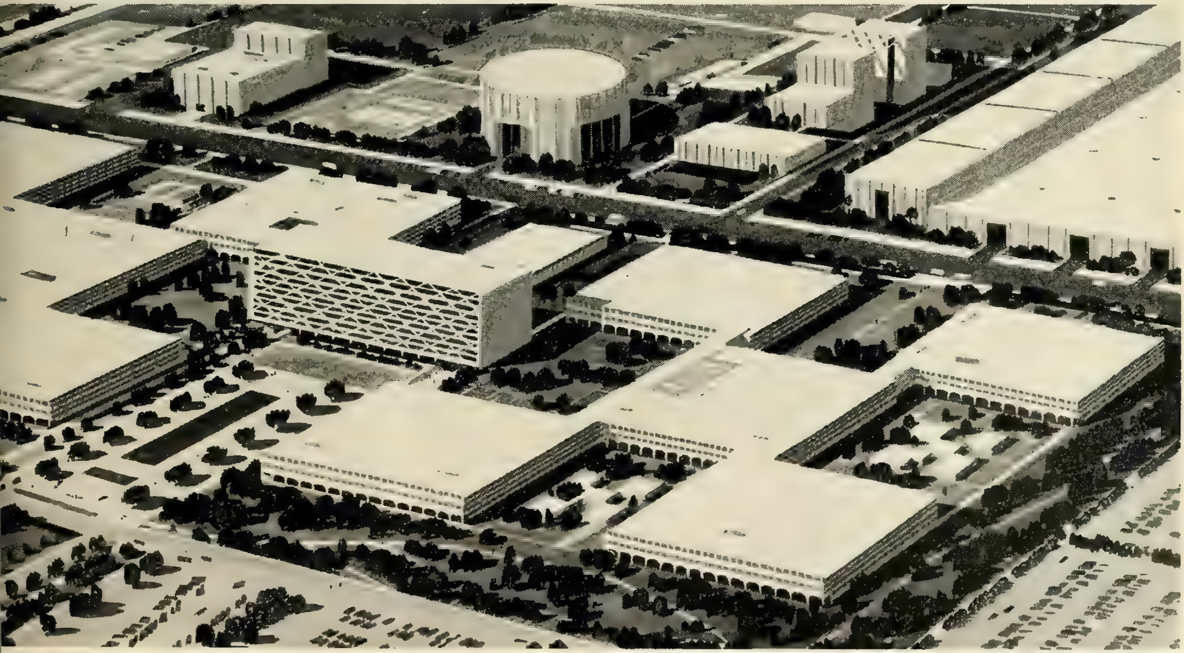


UNITED STATES

MORE BOOST FOR DELTA, world's most reliable space vehicle, is being achieved for the National Aeronautics and Space Administration by utilizing the Air Force/Douglas Improved THOR as first stage. Douglas is developing the thrust-augmented *Delta* (TAD) for NASA's Goddard Space Flight Center. NASA will continue use of the standard Douglas *Delta*.



O STUDY SPACE FROM UP THERE, NASA has ssigned studies of advanced planning for a six man orbiting pace laboratory to Douglas. It could be boosted into orbit y *Saturn* sometime in the '70s. Crewmen, supplies and equipment would be ferried to and from it in *Gemini* capsules. Advantages to be gained from the space laboratory are enormous in such varied fields as weather prediction, medicine, bacteriology, astronomy and many others.



HE NEW DOUGLAS SPACE SYSTEMS CENTER Huntington Beach, California, is one of the world's finest rivately-owned space complexes. Here, talented engineers, ientists and technicians of the company's Missile & Space ystems Division are supported by advanced facilities as they research, test and build systems and vehicles that will help maintain U.S. leadership in space exploration. The new Douglas Center is designed for continued growth. Its capacity will be enlarged to meet the requirements of even more formidable space challenges of the future.

IN THE AIR OR OUTER SPACE...
DOUGLAS GETS THINGS DONE!

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MMRBM missile-borne guidance computer, and to Martin-Denver, *Titan III* prime, for use in that system's guidance computer. In addition, the firm now holds an AF manufacturing-methods contract aimed at improving SIC production yield.

WEC is not supplying any thin-film passive components from its Molecular Electronics Div., nor does it plan "to sell a thin-film passive capability that is now available elsewhere." The firm does maintain an active thin-film hybrid R&D effort, and the next production step for WEC as an add-on to IC's in the future will no doubt include deposition of thin-film passive elements on the insulated active silicon substrate primarily for linear-type applications.

In addition to WEC's original line of DTL circuitry, the firm turns out some TTL and DCTL units, and reports that about 80-90% of its custom circuits are still DTL types. Since setting up the initial line of 12 different linear circuits the firm reports it has been commissioned to do about 25 other types.

Westinghouse IC technology is heavily based upon epitaxial technology and what it considers substantial economic and performance advantages. WEC has put into effect a digitized epitaxial processing system first used 10 months ago for delivered hardware. Some 90% of all circuitry for sale by the firm uses epitaxy, and master engineering specs standardize some 90% of the associated processing.

By refinement of production techniques, WEC scientists predict being able to double the number of gates that currently can be placed effectively on a single 60 x 60-mil silicon chip.

In the offing for the firm's functional blocks in '64 are introduction of surface field-effect transistors for higher impedance, metal-base transistors for greater frequency response, PNPN switching, piezo-electric resonators, and higher value evaporated resistors and capacitors.

Among other microelectronic projects within the division is a new IR search-and-track device to be delivered to the Air Force next month. This device uses a 10 x 10-in. mosaic of single-cell IR detectors, with each cell having a 5-stage microelectronic amplifier. Use of the IC cells for the mosaic and amplifiers removed requirement for gimballing and mechanical scanning.

The firm's Solomon computer, which has received some support from both the AF and Signal Corps, is now being pursued under in-house funds with limited demonstrations held for the services. Should the computer go into production, it would involve a major IC production volume.

Aerojet

Aerojet's Astrionics Division in Azusa, Calif., is spending about $500,000 a year on microelectronics research, chiefly in thin-film circuits. Progress to date includes development of a method of quantitatively measuring thin-film adhesion to substrate materials, and ability to produce pin-hole free films.

Aerojet has developed a technique whereby unencapsulated silicon transistor chips are recessed and bonded into a substrate of ceramic or glass. A thin-film network is then vacuum deposited on the substrate. The circuits have a —65° to 125°C operating range.

The company has deposited and evaluated conductive, resistive, and dielectric thin films on Mylar substrates of 0.001- and 0.002-in. thickness. Gold, copper, and chromium have been used. Prior to film deposition, the Mylar is coated under vacuum with silicon monoxide or refractory oxides to prevent out-gassing.

Aerojet is developing an automated system to deposit totally integrated thin-film circuits, including active elements.

Amelco

Amelco Semiconductor, Mountain View, Calif., a division of Teledyne, Inc., has currently in production 10 members of a compatible logic family: NOR logic DCTL types featuring a proprietary dual collector construction that provides low saturation characteristics.

The circuits are fully integrated on a single monolithic silicon chip and are fully passivated. They range in size from 2,500 sq. mils. to 9,000 sq. mils. Production on these elements is between 3,000 and 6,000 circuits per month, with an existing capacity approximately double that in use.

Amelco has in the pre-production stage two analog circuits; one a low level dc coupled amplifier, and the other a differential amplifier with emitter follower outputs of 1 k ohm.

Presently, Amelco is concentrating approximately 75% of its R&D activity in the microcircuit area, with 20% of gross sales being attributable to this product line. About 40% of their business is in standard transistor devices. The remainder is military business.

Amelco is supplying logic devices for airborne equipment similar to Loran C for an Airborne Instruments Laboratory navigation computer, and is in pre-production on digital devices for HXX Navy computer program.

Autonetics

The Autonetics Div. of North American Aviation, Anaheim, Calif., is a heavy user of microelectronics in the systems it fabricates. At present, the division buys most of its IC's, but produces in-house vacuum-evaporated thin-film circuits, ceramic printed circuits, and multilayer circuit boards. The division has a strong research program in integrated semiconductor devices and is considered by many to be taking steps to become a producer.

Currently the Data Systems Div. of Autonetics is using IC's in the assembly of the D37B *Improved Minuteman computer* and the Monica-J computer. Principal supplier for the D37B is Texas Instruments; principal supplier for Monica-J is Motorola.

The main performance problems experienced with IC's in the D37B have been in obtaining sufficient gain-bandwidth in the sense amplifiers and sufficient noise immunity in logic circuits, due to parasitic capacitance. Package handling has also been a problem.

This spring, the division expects to complete design of a 25-lb. Monica-C—a general-purpose computer for system integration, real-time control, and data-processing.

The Armament Controls Div. is using vacuum-evaporated thin-film passive circuits with add-on active elements in the R45 radar system. The Navigation Systems Div. is producing high-temperature special-purpose passive arrays by the ceramic printed circuit process. These are used in the flight control and inertial measuring unit of the *Improved Minuteman.*

Work on thin-film active IC's in the Research Division includes epitaxial deposition of silicon on to sapphire (heteroepitaxy). Integrated circuits can then be produced by diffusion techniques. Etching through the silicon to the sapphire gives a high degree of isolation between components. Arrays of insulated-gate field-effect transistors, as well as diode-transistor circuits, have been fabricated by this process, but not in production quantities. Autonetics also hopes to deposit gallium-arsenide on sapphire, to provide electro-optical linkages between circuits.

Autonetics is also developing power-starved IC's that use multi-megohm resistors and transistors with collector currents of 1 to 5 microamp. These circuits call for an order of magnitude increase in precision in diffusion technology and optical registration techniques. Sample circuits of this type have been produced.

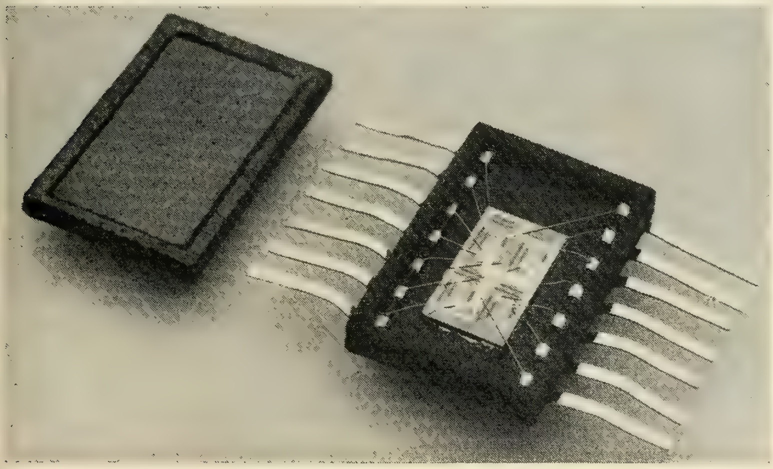
Work is starting on research into electron beam techniques for generating circuits. The beam will be used to initiate chemical reactions at 10^{-4} Torr and to form active elements with alloyed and diffused junctions. It will also be used for beam milling.

The research laboratories are also investigating use of an electron beam in a glow discharge system for laying down thin films of organic semiconductors for large area coverage photodetectors.

The Data Systems Div. has announced that it has succeeded in producing single-crystal silicon on a polycrystalline silicon substrate. The single crystal is described as Czochralski-grown, so this process differs from the sapphire-base process in that the silicon crystallizes from a liquid and not a vapor.

Bendix

Bendix Corporation's program in microelectronics, involving in-house use and out-of-house sale of both IC and thin-film hybrid circuitry, is expected to expand significantly within the next two years.



HUGHES quadralogic integrated network in a 14-lead glass package before final seal. Circuits are fabricated on a monolithic silicon substrate.

Key to the expansion is the firm's Semiconductor Div., which supplies other Bendix operating divisions with silicon "master" slices for subsequent custom design and processing, usually involving deposition of thin-film passive componentry, in the individual divisions.

At present, Bendix officials told M/R, the division turns out about 500 master slices each month, each slice generally yielding 20 microcircuits. Within the next two years, Bendix predicts this capability will be expanded to 2,000 slices a month.

Increase in wafer production also will increase the firm's ability to turn out individual IC digital building blocks, which it now markets through the Semiconductor Div., primarily to supply other Bendix divisions. Output of 3,000 circuits per month currently—mostly flipflops, NOR, and NAND gates—is expected to hit at least 12,000 per month.

Present combined microcircuit production capacity of divisions where IC production is available—Eclipse-Pioneer, Bendix-Radio, Research Labs, Pioneer-Central, Systems, and Semiconductor—is 8,500 circuits per month.

Two new facilities are being set up at Eclipse-Pioneer, one for fabrication of engineering models and the other for production of pilot runs. Scintilla Div. manufactures the hermetically sealed IC casings, and passive substrates for thin-film work.

New resistor materials being researched include nickel-chromium alloys, tin-oxide films, and silicon monoxide-chronium cermets. Silicon monoxide, tantalum oxide and several titanates are being researched for improved deposited capacitor performance.

For some communications, radar, and power amplifier devices, the firm is also using passive thin-film circuits, use of which it feels will continue for several years. Porting of these circuits in semi-ceramics that have high thermal conductivity further enhances power handling capability, they report.

Bendix anticipates that microcircuitry will be used in all low power applications for Bendix equipment. This will range from about 1% of the applicable electronics business in 1965 to 85% by 1972.

Burroughs

Burroughs Corp. engineers report that the firm will attempt to build up an in-house capability for turning out thin-film hybrid circuits to supply the major part of the firm's IC needs for new data processing systems.

For example, the Advanced Fabrication Technology Dept. at Paoli, Pa., is now turning out devices to be used in a new high-density memory to be introduced this year with a new data processing system.

The effort is directed primarily at hybrids using alumina or glass substrates and deposited thin-film passive networks. The firm will continue to buy active elements for attachment.

In the active thin-film area, Burroughs has developed a polycrystal space-charge-limited triode after earlier exploration of tunnel triode devices, which it says it has produced in batches of 40, making several runs each day in company-designed vacuum deposition chambers. Effort is now aimed at improving characteristic reproducibility.

Eventually, Burroughs sees development of complete active thin-film logic nets eliminating all passive componentry.

The feeling at Burroughs is that in-house development of suitable memory IC's is a must in order to get the high densities the firm wants. Circuitry of this type is not generally available today, they claim, and though "the IC's associated with the arithmetic portion of EDP systems appears to be well in hand, the memory area needs attention, which might not be done by the component manufacturer."

In magnetic thin films, the firm is studying possibilities for achieving an order of magnitude improvement in bit densities, particularly for very large scale memories of 10^6 bits and up, and for small volume aerospace systems. One technique under study involves fully deposited thin-film memory sheets, including driver lines, in a vacuum process.

Electro-Optical Systems

Electro-Optical Systems, Inc., Pasadena, Calif., is experimenting with the vacuum deposition of thin film of tantalum on diffused silicon substrates. A four-input gate being studied measures about 1/10 in. square. EOS is making micro strain-gauge networks (0.018 by 0.020 inch) in silicon for use in mechanical transducers. These are marketed by its subsidiary, Micro Systems Inc. Another area of research is the development of gallium arsenide diode arrays with 0.005-in. and 0.010-in.-dia. photosensitive areas for optical orientation systems.

EOS has produced diode-resistor networks in thin-film form in laboratory quantities, using a three-layer structure of tantalum, anodic tantalum oxide and gold.

General Electric

General Electric Co.'s activities in microelectronics will expand slightly in

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1964, primarily at the firm's Light Military Electronics Div. in Utica, N.Y.

LMED, which put an extensive thin-film circuit production capability into operation in 1962, will add new diffusion equipment to allow greater capability in silicon-base semiconductor technology. LMED's J. H. Cunningham, microelectronics marketing manager, points out, however, that the division will not enter into competition with GE's Semiconductor Products Div. for IC out-of-house sales. LMED will use the facilities for research and small quantity, selective purpose production. Large quantity IC needs for LMED's aerospace equipment will still be supplied by outside sources and GE's Semiconductor Products Div.

With the thin-film manufacturing activity at LMED, Utica has also become a focal point for new thin-film hybrid development for which the firm holds great promise.

By mid-year the division expects to be able to turn out a wide range of IC's in addition to having passive thin-film capability. The combination of techniques has also led to LMED's in-house role as developer of the new "flip-chip" hybrid program within GE, wherein silicon chips or functional blocks are mounted working-face down on a thin-film interconnection substrate.

From more conventional thin-film passive substrate hybrids, GE expects its capability to evolve into flip-chip production for GE equipments—possibly in 6-8 months. Out-of-house sales, either by LMED or Semiconductor Products, in the future is also possible.

Research into thin-film active elements, and other silicon-base hybrids, is carried on at the firm's Electronics Laboratories at Syracuse. Major effort reportedly is aimed at cadmium-sulfide thin-film field-effect triodes, though some work is still being carried on in single crystal deposition. E-Labs reports it has fabricated a thin-film triode with a transconductance of 500 micro ohms, power gains of about 500, and current loads of from 1 to 5 milliamp. New research is aimed at refined masking techniques for closer electrode spacing and protection against moisture, which threatens shelf-life of these devices. E-Labs holds a contract to study field-effect failure mechanisms.

GE is researching and experimentally fabricating optoelectronic devices incorporating electroluminescent and photoconductive technology. Materials of this type, according to the firm, can be deposited in multi-element thin-film form, and since they can be coupled optically rather than electrically, applications in fault isolation and detection in microcircuits and standardization of interconnections are possible.

Also at Syracuse, GE is exploiting in the lab what could be a major new process for thin-film manufacture, that of glow discharge. Scientists see this technique, which can operate at near room temperatures, as possibly holding the key to use of thin films on a wide range of novel substrates and for forming many components in thin film now thought to be beyond the technology.

GE's Semiconductor Div. is supplying some integrated circuits for Minuteman, and LMED holds several R&D contracts in which small numbers of units using IC's will be produced. Included in these is a missile encoder for Johns Hopkins University's Applied Physics Lab (M/R, Jan. 6, p. 21), video amplifiers for the Office of Naval Research, and a new contract from the Naval Research Lab to develop a hybrid thin-film microcircuit shift register. This will be a single hermetically sealed package containing die-attached silicon circuit chips mounted face-up to a thin-film substrate with deposited interconnections.

General Micro-electronics

General Micro-electronics moved into new facilities in Santa Clara, Calif., in August and was producing integrated circuits 2½ months later. To speed entry into production, the company bought masks, but is now installing photographic mask making facilities. Currently two assembly lines are in operation; there are plans for 10 more.

GME intends to offer all forms of logic off-the-shelf, ultimately six to seven families. The first series produced is DCTL and has an average dissipation per function of 4-10 mw; with typically 2 mw per node.

To improve its capability to secure systems contracts, GME, according to Arthur C. Lowell, president, is developing a systems division interested in such things as analog/digital converters, but not intending to go above sub-system level.

GME plans to spend 10-20% of its gross sales on R&D and will sponsor university research.

General Precision

Microelectronic activity within General Precision Inc.'s Kearfott Div., part of the firm's Aerospace Group, is directed at in-house production and use of custom analog circuitry primarily for inertial guidance systems in which the volume of any specific circuit, according to GPI, is not as large as a similar circuit in digital form. Toward this end, the firm is developing thin-film resistor-conductor networks deposited on a ceramic substrate used with attached active and capacitor elements.

The firm continues to buy digital components externally. In-house effort is reportedly $0.5 million annually.

Hamilton-Standard

Hamilton-Standard Div. of United Aircraft Corp. and the Army's Electronics R&D Lab at Ft. Monmouth are conducting a jointly sponsored program to establish a pilot production line for the Army's new Micro-Circuit Module, a second generation outgrowth of earlier work on the MicroModule designed to incorporate latest semiconductor and thin-film hybrid integrated circuits into the assembled package.

The pilot facility at Hamilton Standard, aimed at developing manufacturing environment techniques and Mil Spec qualification of the package, is expected to produce Micro-Circuit packages at the rate of 100 per 8-hr. day, with performance runs expected to be completed this spring. An assembly cost goal of $4 per module had been established, and engineers report that experience with an unbalanced pilot line has already shown this "can be easily achieved."

Should the pilot runs show feasibility, observers close to the program speculate that follow-on production numbering thousands of circuits could come, possibly next year.

Basic element in the package is the 0.310 wafer, with package dimensions retained so that elements developed in earlier work could be incorporated. Typical module contains 10 wafers in a stacked array. Extensive use is made of Hamilton-Zeiss high energy density electron beam welders for interconnections.

Hamilton Standard has also received considerable Air Force support in recent years for new pilot production developments using electron beam methods associated with microcircuits.

Currently in-house are two contracts from the Air Force Manufacturing Technology Lab. One is aimed at an assembly system operable in extreme thermal environments (200°C.) without compromising reliability, and the other at an advanced process and analysis system for experimental fabrication of a wide range of IC's.

Object of the latter program, according to the firm, is a system that permits fabrication and analysis functions to be carried out without exposing the devices to deleterious environments. It is planned to include stations within the system for epitaxial growth by thermal reaction, diffusion, electron beam and laser beam processes, and multisource thermal evaporation in ultrahigh vacuum.

Preliminary design studies have been

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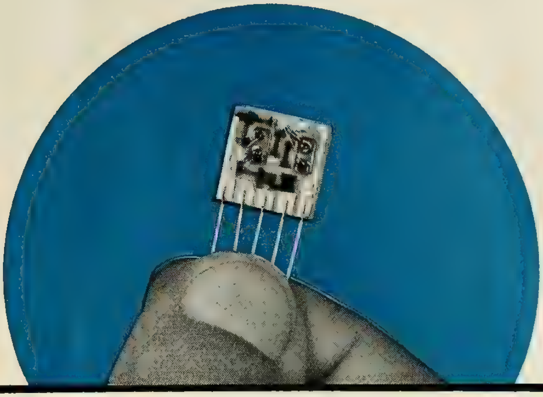

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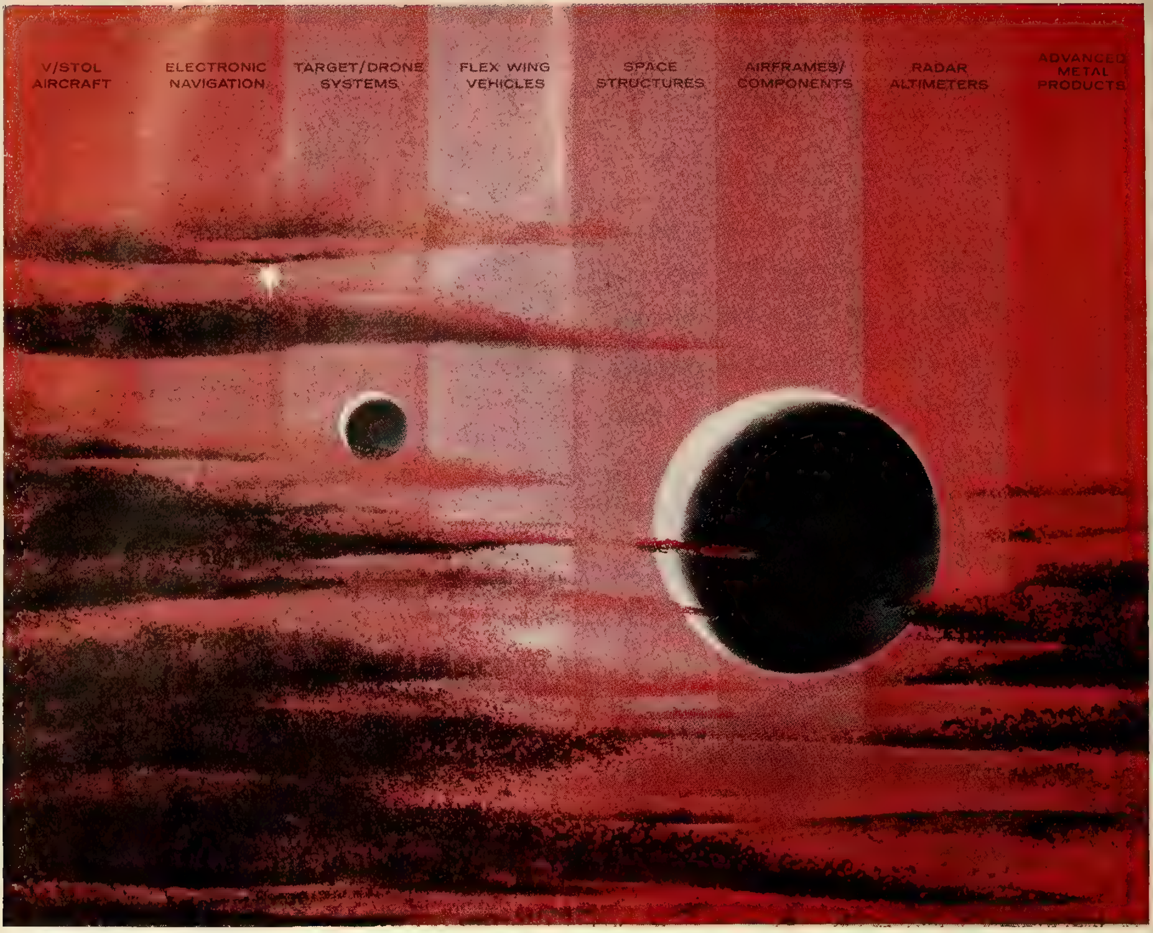
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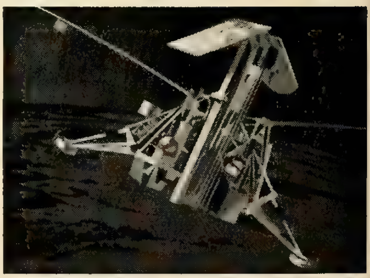

SURVEYOR SPACECRAFT — Ryan Electronics was selected by Hughes Aircraft to design, develop, and fabricate the Radar Altimeter and Doppler Velocity Sensor equipment for this NASA/JPL Lunar Soft Landing System.

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completed. Present plans call for a system of three distinct environmentally controlled chambers interconnected by ultrahigh vacuum interlocks and workpiece transport mechanisms.

Honeywell

Pilot production of planar epitaxially grown silicon digital logic circuits is under way at Honeywell's Semiconductor Products Div.'s R&D center at Riviera Beach, Fla., for a new aerospace computer in development at the firm's Aeronautical Div. facility at St. Petersburg, Fla.

The modular computer features a new molecular diffusion packaging technique said to extend the IC packaging process from the chip or circuit dice level to the functional level.

Honeywell's new "chip level packaging" contains, in one case, an integrated package of 25 IC's, "intra-connected" on a multilayer substrate to make a three-bit binary adder.

The encapsulated adder package contains some 400 transistors and 250 resistors on a single substrate "not much larger than a postage stamp; the junctions between circuits are continuous with no 'interfaces' of material changes."

Engineers report the new packaging process should offer the same 50-to-1 reliability advantage over conventionally interconnected IC flat packs as flat packs have over conventionally interconnected discrete components.

Since the molecular diffusion process can also be applied to card-to-module connections, they said, far fewer cards per module are necessary and simpler production and servicing steps are required.

The Riviera Beach facility produces both digital and analog circuit elements and is experimenting with additional devices. Transistor-transistor logic (TTL), high-level transistor (HLTL), and milliwatt (MWL) have been chosen as the most promising digital logic systems for missile/space applications. HLTL shows particularly promising speed and drive capabilities, they report.

Hughes

Hughes has recently consolidated its microelectronic R&D programs within the Semiconductor Div. in Newport Beach, Calif.; primarily to give the major systems business at Hughes a microelectronic capability. Four technological approaches are being developed.

Microseal circuits use active and passive pellet components inserted in a "Swiss Cheese" printed circuit board and are currently in production. Several computer companies have ordered boards of this type. Hughes claims it is the only supplier of active devices of the pellet type.

Hughes expects to market Microseal diodes encapsulated in glass in the first quarter of this year and Microseal transistors in glass in the second quarter. These should be cheaper than the present ceramic encapsulated devices.

The other approaches at Hughes are use of active pellet components with passive thin films, deposition of thin-film passives on an active silicon substrate, and fully integrated circuits with thin-film active components.

In active silicon substrate work, Hughes is using an iterative cell approach to give a function module rather than a circuit type. Basically four circuits are needed: a flip-flop and three different gates. Using a 4-input T^2L NAND gate as a building block, Hughes has come up with "Quadralogic", in which there are four circuits per chip and four devices per circuit. Variations in module function are achieved by variations in the final deposited aluminum interconnection pattern. The Guidance Systems Group at Hughes is using six functions achieved with these iterative cells to build a computer.

Deposited nichrome resistors are used in these circuits, so that a variety of circuits can be obtained at the cost of changing only two masks (resistor and interconnection).

Hughes is working on a multiple-source vacuum chamber to deposit nichrome and aluminum without intermediate reloading of the chamber.

The Semiconductor Div. also is working on a pre-amplifier for the lead-sulfide cell array in the *Phoenix* missile. This circuit contains about half a megohm of resistors, and has to have a high input impedance and low noise figure. The high resistor requirement has meant use of deposited cermets. The final circuit has 5 devices, an input impedance of 1 megohm, a gain of 100, and a noise figure of less than 3 db. These circuits are now being delivered, in ⅜ x ¼-in. flat packs.

Hughes also is producing a 3-mc TFX operational amplifier in integrated form. It has additional applications as a 30-db differential-amplifier and as a post-Doppler filter amplifier.

E. B. Gould III, manager of Hughes' microelectronics program, estimates that a good linear amplifier with a bandwidth up to 1 mc. will be the first widely used analog circuit, and he suggests that this will be a much bigger market than people think.

Hughes is developing a line of T^2L devices, and will probably market them at the end of this quarter. (Currently they are developing a circuit of this type for the Litton computer in the TFX.) However, Hughes sees much of its business in custom logic and hopes that by the use of deposited resistors the circuit designer will be put back in the game. To this end they may market a form of building-block kit that simulates various aspects of their circuits. For example, using adhesive-tape resistors.

In thin-film active devices, Hughes is working on space-charge current-limited triodes, field and tunnel emission devices, and double-injection phenomena. Arrays of cadmium-sulphide diodes have been made, and some triode and pentode-like structures. Materials investigated include zinc sulphide, zinc telluride, cadmium selenide and cadmium telluride. Some devices have shown shelf lives exceeding two years, without passivation. Yields of devices now show stable characteristics. Some thin-film metal-base transistors also have been built. Engineering samples of thin-film active devices should be available for evaluation by the end of 1964.

Tests with a linear accelerator show that the thin-film devices have considerable more radiation resistance than diffused silicon devices, both in relation to total dosage and radiation shock.

Gould suggests that this means that thin-film active devices will find application before they are economical and before they have good frequency characteristics, simply because they will work where other devices cannot.

Integrated digital and selected linear circuits will be the biggest selling products from the Microelectronics Division. They make up about ⅔-¾ of forecast sales for 1964, and a higher proportion thereafter. But a better assembly technique for Microseal circuits could change this picture.

In research, Hughes is looking at various glass techniques for encapsulation, using pyrolytic decomposition. A diode capability has been developed and Hughes aims to apply these techniques to IC's. Hughes has also proposed a technique for using distributed thin films in a logic-memory system for a computer, together with use of opto-electronic devices (arrays of gallium arsenide) to reduce the interconnection problem. Lasering properties may offer additional advantages for interconnection because of the capability of modulation. Work has been done on electron beams and lasers for machining and interconnections. A laser with a longer duty cycle will have very interesting applications, especially for making high definition masks.

About 20% of the Semiconductor Div.'s business will be in microelectronics this year (including R&D). In three years this will rise to 50%.

Intellux

Intellux Inc., Santa Barbara, Calif., produces thin-film passive tin-oxide circuits on glass substrates. These are induction soldered onto pads on a header that carries active devices in TO-5 cans.

In February, the company expects a backlog of orders of $50,000 per month, rising to $100,000 per month by the end of the year. Intellux says it gained valuable experience in all microelectronics packaging problems because they supply multilayer circuit boards throughout the industry. Currently the company produces about 1,500 circuits a week. Their maximum production with current facilities would be 120,000 circuits a week.

International Business Machines

International Business Machines, Inc., which remains tight-lipped about its in-house production scale, did give some indication of which way its IC technology may be going, at least as an interim approach, in a presentation made at WESCON this summer. IBM reported on a new low-cost method of fabricating hybrid IC's using semiconductor chips and deposited passive components without the use of thermo-compression bonding and without hermetic sealing (M/R, Aug. 26, p. 28).

The firm is heavily based in thin-film technology, has worked with a great variety of materials in its deposition studies, and performed early development of sequential inline automatic production equipment.

International Resistance

Following a decision to place major emphasis on development and sale of passive substrate hybrid IC's as opposed to silicon-based IC's, International Resistance Co. of Philadelphia, announced availability of the first of these circuits for sale at the recent Wescon meeting in San Francisco.

Alumina wafers form the basis for the entire assembly. A proprietary metal glaze ceramic material, which functions as a conductive material and as a resistive element, is screened on each wafer in a pattern and fired at high temperatures. Capacitors, diodes, and transistors are brazed on, with final connection made by thermo-compression bonding of gold leads from the chips to the conductive pattern. The wafer (or wafers) are mounted and hermetically sealed in TO-5 cans. Flat-pack hybrids are also available.

IRC reports that it produces all the active and passive elements going into the hybrid, using active devices produced by epitaxial multiple diffusion processes and ceramic-type capacitors based on barium titanate material.

In advanced R&D, scientists are studying the field-effect device in solid-state form, and also in a thin-film version, and the fully integrated thin-film circuit.

IRC reports it has made diffused field-effect devices but has no present plans to market them. Research is aimed at field-effect-based circuits rather than componentry. The active thin-film development is primarily aimed at a metal interface amplifier type of device using aluminum oxide and a variety of polycrystalline materials.

International Telephone and Telegraph

International Telephone and Telegraph Co. is now building a $3-million plant in West Palm Beach, Fla., for IC manufacture. Also, at the firm's Federal Laboratories in Nutley, N.J., more than $1 million has been programmed for microelectronics R&D in 1964.

Physical Sciences Lab at Nutley is developing thin-film-base devices for in-house applications including 70-mc amplifiers and other analog circuits.

An evaluation of current IC techniques for missile/space use undertaken by ITT shows that a hybrid approach using "thick" film passive components deposited upon a ceramic substrate in combination with discrete pellet-type transistors and diodes offers the most reliable configuration obtainable within practical cost and time limitations.

Among points made in favor of this approach, ITT cites good stability under high ambient temperatures, achieved through use of a high thermal conductivity substrate material, such as beryllium oxide, in intimate contact with circuit elements. Also, they note, RF shielding between wafer assemblies can be easily obtained through use of deposited metallic films, such as silver, on the undersides of the sensitive wafers. The use of brush-depositing and etching techniques provides good breadboarding flexibility for both analog and digital circuits.

ITT scientists told M/R there are about five new individual circuits now under consideration by the firm. These include: An IC to perform conversion from parallel bit binary digits to analog d.c. output; another, to perform diode frequency multiplication of an RF envelope; a third IC is aimed at high-frequency band-pass amplification without the use of inductors; another is

PLASTIC MOCKUP of one of FLIP series of inertial platforms being developed by Northrop Nortronics. Featuring a floated inertial sphere rather than gimbals, the platform is designed as a low-cost system offering all-altitude capability.

aimed at permitting clocked sample-and-hold of a time-varying waveform; and finally, an IC with adaptive ability to alter its internal transfer function as a result of external feedback signals, or as a result of internal "voting" analysis of the input signals being received.

Lear Siegler

Two divisions (Astronics and Instruments) of Lear Siegler, Inc., Santa Monica, Calif., have microcircuit facilities. These carry on independent R&D and production activities. The LSi Research Laboratory is investigating active thin-film devices, and studying the possible use of unipolar insulated-gate structures and optically-coupled devices.

LSi has developed the "Millimin" packaging technique. Potted and tested microcircuit modules are assembled by function onto a keyed Millimin module card which is, in turn, mounted in a one-, two-, or three-cell cast aluminum frame, depending on system or unit function.

Ling-Temco-Vought

Ling-Temco-Vought Inc.'s Military Electronics division in Dallas has a capability to produce thin-film circuits—primarily for users throughout LTV. Emphasis is on production of special circuits not available commercially, and chiefly analog and special digital circuits. The company sees thin films as most promising for missile/space applications.

Plans for new facilities include ultra-high vacuum systems and thin-film semiconductor laboratories. Less than 1% of LTV's business is associated with microelectronics, but a rapid increase is expected.

Litton Industries

The Guidance and Control Div. of Litton Industries, Woodland Hills, Calif. holds the contract for the computer and associated electronic systems to be used in the TFX in conjunction with the *Phoenix* missile. The computer contains 5,000-7,000 IC's, with mainly discrete components in the associated electronics, notably the display. The feature of this computer is the large number of circuits involved and the biggest problem is noise immunity. Circuits available as catalog items did not have big enough noise margins and a great deal of Litton's design effort went into obtaining a noise-immune circuit. Basically, a single circuit type is being used in this computer, which has become known throughout the industry as the TFX-gate.

Companies cooperating with Litton in its development include Fairchild, Motorola, Sylvania, TRW Semiconductor, and Philco. Litton has a laboratory IC line for producing experimental quantities, providing a basis for evaluating vendor performance.

Litton has been praised by a number of IC manufacturers for the specification they put out for the TFX-gate. Litton engineers say that the circuits available off-the-shelf were not systems oriented because the manufacturers had not looked into the ramifications of the use of very large numbers of their devices in one system. Litton embarked on an extensive engineering effort to evaluate what was possible in IC's and designed their spec around this. Furthermore, the company modifies its spec to improve the manufacturer's yield, whenever possible.

As regards the package, the division gave a range of dimensions that would be suitable, specifying position of leads. They have been supplied with five different size packages, all of which have been accepted.

The division is producing an inertial guidance platform under a Navy BuWeps contract, using Texas Instruments circuits, and is developing a digital computer in-house.

Litton has also started construction of a 20,000-sq.-ft. plant at Springfield, Mo., for development and manufacture of multi-planar interconnect systems, "Polyweld" weldable circuits, multiplanar weldable circuits, and conventional printed circuits. It will house the Advanced Circuitry division of Litton Precision Products, Inc.

Lockheed

Over the past four years the Electronic Sciences Laboratory of Lockheed Missiles and Space Company, Sunnyvale, Calif., has been developing a versatile and cheap process for forming thin-film passive networks in titanium, intended for satellite applications where long-life and radiation resistance were prime requirements. Titanium, like other refractory metals, is not only radiation resistant but has three stable oxides, providing a range of resistive, dielectric, and active properties.

A 12-minute 500°C molten salt process deposits titanium on a ceramic substrate. Lockheed subsequently uses a combination of copper deposition and etching to achieve the desired network. Deposition on screw-threads tapped in the substrate can provide inductive elements. Anodization of the titanium by an electrolyte produces titanium dioxide. This dielectric yields capacitors of 0.015 μf/sq. cm. when a silver counter electrode is painted on the oxide. Any kind of discrete active element can be attached to the circuit.

Within a year, LMSC expects to make diodes in rutile (T_1O_2).

Currently LMSC is depositing 8 NAND circuits on a 1-in. square wafer. These can be interconnected in various ways to give 469 different logic functions.

LMSC aims to license its process to other manufacturers rather than set up as a circuit producer.

Nortronics

A fabrication and evaluation facility has been established by the Northrop Nortronic's Electronic Systems and Equipment Department in Palos Verdes, Calif. Computer technology has received the greatest attention.

The company is now utilizing integrated circuitry to develop the high-speed airborne general-purpose computer NDC-1000. This uses about 1,400 microcircuits in 95% of its circuitry. Main supplier is Signetics.

Nortronics is also using microelectronics in inertial platforms. An example is the company's FLIP (for Floated Low-Cost Inertial Platform), designed as a low cost system for a multitude of aerospace uses. The FLIP series of platforms feature a floated inertial sphere and microelectronics for 90% of the associated electronics to achieve economy and all-altitude capability.

Molectro

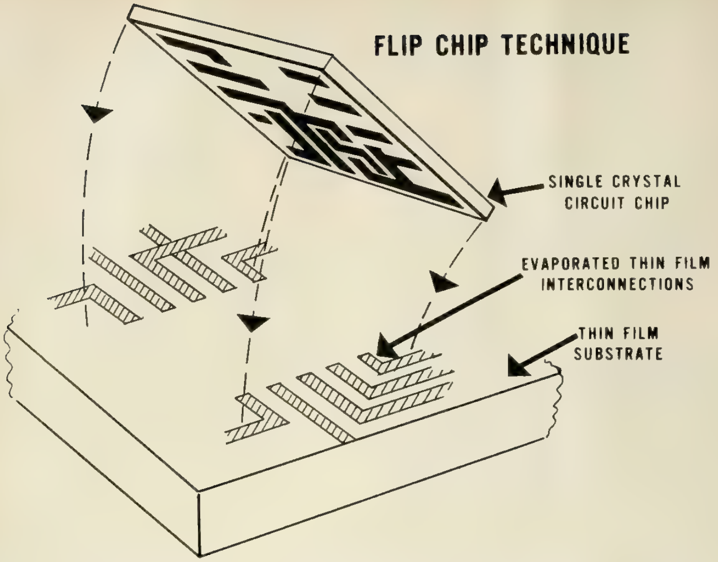
Molectro Corporation, Santa Clara, Calif., formed in June of 1963, is currently equipping its assembly line. Hitherto, work has been concentrated on developing a mask-making and diffusion facility. The first product line planned is an integrated circuit called "Data-Pak," which contains four pairs of transistors and 12 resistors. The customer specifies the interconnection pattern for the chip, and so retains a measure of control over the digital circuit he uses. Other products in this line are chips that can be used in amplifiers, communication networks, and power supply controls.

James R. Nall, President of Molectro, sees considerable potential in the process of thin-film deposition over active silicon substrates, and the firm will push this line of development, particularly multiple layers of thin film.

Philco

Philco Corp., following on the heels of its decision last fall to drop many of its production transistor lines and the subsequent decision to set up an expanded Microelectronics Operation aimed at increasing IC development and production, is expected to have available its intitial IC product line by next month. The firm will concentrate on silicon epitaxial IC's.

Under a cross licensing agreement with Fairchild, Philco will start turning out a line of Micrologic planar epitaxial semiconductor devices. The firm


FLIP CHIP TECHNIQUE
SINGLE CRYSTAL CIRCUIT CHIP
EVAPORATED THIN FILM INTERCONNECTIONS
THIN FILM SUBSTRATE

GENERAL ELECTRIC'S new "flip-chip" technique bonds chips face down on thin-film interconnection network, is thought to have considerable potential.

also plans to market Philco custom SIC's, TTL digital circuits, and a Fairchild milliwatt logic line later in the year.

Also in 1964, the Lansdale, Pennsylvania-based operation is expected to be producing some custom hybrid thin-film networks, primarily for linear applications, for both in-house Philco programs and for external sale.

The Philco hybrid approach is not yet firm, but Dr. Charles Sutcliffe, manager of the firm's new Microelectronic Operations, told M/R that use of attached active elements on a deposited thin-film tantalum network is most likely based on expected cost and high frequency advantages.

Reasoning behind the initial paralleling of the Fairchild line was based on the idea of becoming a second source on one of the most widely used lines as a starter rather than hoping to introduce another basic competitor to an already wide base, according to the firm.

Philco's entry into IC production was no doubt helped through acquisition of the firm as a subsidiary by the Ford Motor Co. Philco officials told M/R the firm plans to spend at least $5 million on its IC capability in the next few years, a large chunk coming this year to set up its relatively new Lansdale plant to handle the manufacture. The firm reportedly will supply IC's on the F-111 *Phoenix* missile computer.

Radio Corp. of America

Corporate decisions made recently at RCA have set in motion a planned large-scale movement into semiconductor integrated-circuit manufacturing. Earlier entry by RCA into the IC market, according to observers, was no doubt slowed by the firm's major long-term early involvement in the Army Signal Corps' $18 million Micro-Module program.

The RCA IC commitment involves spending "several millions each year," an expense initiated during 1963 and one that will extend beyond 1964. Support for the program, centered in the Somerville, N.J., manufacing facility, comes primarily from the firm's Defense Electronics Products Div.

Initially the firm will expand engineering and production facilities, including a new 6,000-sq. ft. clean room, for integrated silicon-base circuits, turning out mostly bi-polar type devices. Major production capability is expected by mid-1964. Eventually (still a minimum of one year away), Somerville also is expected to turn out production quantities of RCA's metal-oxide-semiconductor (MOS) silicon-based logic nets, now in advanced research stage at the firm's Sarnoff Laboratory in Princeton, N.J. Still farther down the road, RCA scientists feel the firm may gravitate toward production of hybrid thin-film circuits using the silicon base, prior to development of pure thin-film circuits.

Officials told M/R that present manufacturing plans are aimed solely at in-house needs, particularly in the defense area. By 1965, production capacity may exceed projected in-house needs, allowing the firm to market out-of-house.

RCA estimates that IC's will represent, in one form or another, about 25% of corporate hardware sales in the future.

The RCA long range research effort, carried out at the Sarnoff Center with some shorter range effort at the divisional level, is aimed heavily at circuits, designed around MOS insulated-gate field-effect active devices, both in the silicon-base IC form and in the thin-film active element area, according to Dr. William Webster, director of electronics research at the center.

Raytheon

A new thin film circuit facility at Raytheon's Missile Systems Div. in Bedford, Mass., has been completed and is beginning to turn out limited quantities of hybrid IC's solely for in-house requirements.

The facility, started in late 1962 and representing about a $1-million investment by the firm, includes a new state-of-the-art evaporation system with a single vacuum cycle multiple-film deposition capability and automatic feed and monitoring.

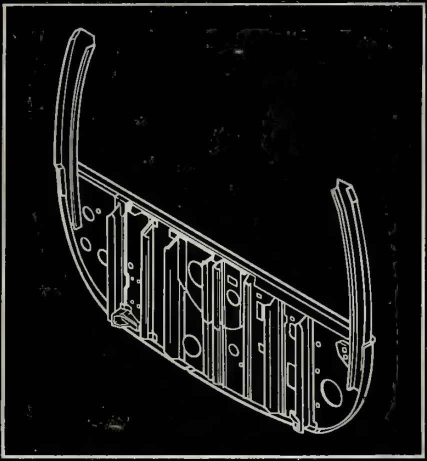
The evaporator has 10 stations, each capable of handling five substrates. Cycle time is about one hour, allowing for production of 50 multilayer thin-film networks at a clip.

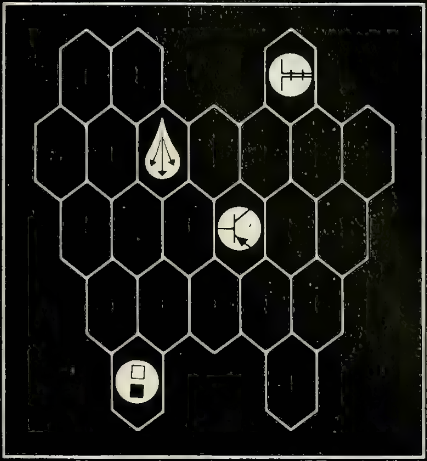
Raytheon is now said to be spending about $0.5 million annually on expanding its microelectronics capabilities.

The current Bedford effort is aimed at evaporating a nichrome resistor film upon an 0.8 x 0.8-in. passive substrate using a silicon monoxide insulator and gold conductors, with attachment of active elements and capacitors. Within a few months, the firm hopes to introduce its own capacitors into the package, fabricated in the same evaporation cycle as the resistors using a silicon monoxide dielectric with aluminum or gold plates. Also in the offing is use of a cermet resistor, a higher dielectric for larger value capacitors, and a hermetic seal for the now-encapsulated device.

Raytheon uses primarily electron beam evaporation for the nichrome network. Gold external leaders are attached by soldering, and the firm reports development of a new lower temperature bonding scheme for attachment of active elements. There is no plan now to market these devices externally.

At the firm's Semiconductor Div. in Mountainview, Calif., a more extensive production line is being set up to handle





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a full line of new digital type circuits, probably DTL using single silicon wafers with diffused components, which is expected to be introduced this year. Mountainview, which carries out the Raytheon effort in IC technology, since mid-1963 has been supplying DCTL NOR-gates for use in the *Apollo* computer. The division has also carried out some exploratory fabrication of *Apollo* NOR-gates using nichrome thin-film resistors and an active substrate, but further proof-testing will be required before consideration for *Apollo* use.

In addition to *Apollo,* Raytheon microcircuits are used in portions of *Mauler* GSE, and in Army PCM ground equipment.

Siliconix

Siliconix, Inc., Sunnyvale, Calif., expects to become a specialty supplier in the integrated circuit business, based on earlier work in field-effect transistors.

P-type doped slices are purchased from several suppliers. The company does its own lapping and epitaxial growth, a technique that is used 100% and produces its own masks. Headers are supplied from outside but the company has recently developed its own flat pack. In this, the chip leads and lead frame are sealed in a layer of glass between two alumina plates. The chip and leads are thus encapsulated in glass. The package is said to be cheap (only three piece parts) and redesignable in shape at low cost. Problem at present is how to test for leakage. Probable answer will be immersion in a salt bath.

Siliconix has been slower coming to the IC market than planned, but is now marketing a line of 10-mc DTL logics capable of operating with a single 5-v power supply. The circuit is available in seven forms.

About 70% of the firm's R&D is now devoted to integrated circuits—a reversal of last year's position.

Sprague Electric

Microelectronics R&D at Sprague Electric Co. is aimed at exploiting combinations of devices and techniques with single semiconductor chips—such as NPN/PNP transistors, field-effect transistors, distributed parameter networks—along with compatible thin-film components on the passivated surface of the chip.

In addition, the firm reports it is developing techniques for linear circuits in monolithic IC form; new processing methods that will allow combination of cleaning, epitaxy, oxidation, and diffusion within a single closed system; a new thin-film and semiconductor interconnection schemes.

The firm, which maintains research facilities and two engineering pilot lines at its North Adams, Mass., headquarters in addition to pilot plant and production facilities in Concord and Nashua, N.H., reports that it will soon introduce a new line of high-speed transistor diode logic circuits based upon improved epitaxial and diffusion techniques.

Sylvania Electric

Sylvania Electric Products, Inc., a subsidiary of General Telephone & Electronics Corp., plans some expansion at both its Woburn, Mass., Semiconductor Div. and its Electronic Systems Div. at Waltham, Mass., this year.

The Semiconductor Div., heavily based in silicon epitaxial technology, has built some digital circuitry functioning at over 30 mc and plans to add additional custom circuits both digital and analog to its basic line of fast digital logic, mostly TTL. Some 75% of the division's sales are external to Sylvania.

The firm's thin film activity, centered in ESD at Waltham, is oriented toward fulfilling in-house and government agency hybrid circuit requirements. There is currently no external sale of these devices, used in both digital and linear applications, however a corporate decision on future out-of-house sale is expected within six months.

Current hybrid thin-film approach uses a range of ceramic, glass, and glazed ceramic substrates with attached (by solder or welding) active elements. The firm has used silicon monoxide in most of its thin-film work to date, but plans to add a tantalum capability by June. In research, work is aimed at exploring use of titanium-dioxide films.

Gerald J. Selvin, Microelectronics Manager at ESD, told M/R that the division believes in carrying a balanced mix in thin-film methods, including vacuum depositions, sputtering, and screen and fired processing, in order to satisfy what is still considered a wide range in customer requirements. "We find that it is unwise to operate fully programmed," says Selvin, "since different Government groups do have preferences."

Sylvania has invested about $1.5 million in its thin-film capabilities in the past three years and plans to spend something under $0.5 million this year to expand facilities, adding the tantalum capability.

In the lab at ESD, Sylvania engineers are forming silicon thin-film transistors and diodes on a glazed ceramic substrate by both vacuum decomposition and evaporation processes. This effort has received Air Force, Navy, and corporate support. Sylvania says the TFT is certainly a "highly ordered device" when discussing its single-crystal properties, pointing out the difficulties of analyzing properties of micron-thick films on polycrystal substrates. "The characteristics are good," they add, "and that is what is really important. We are most optimistic about these devices."

Scientists also are working with some of the non-classical materials such as the semiconducting oxide of titanium in a vacuum system, forming "preliminary diodes." ESD is currently supplying thin-film hybrids for two BuShips and BuWeps equipments.

TRW Semiconductor

TRW Semiconductor Inc. in Lawndale, Calif. produces a range of IC's using transistor-coupled logic. The company has certain common research programs with other subsidiaries—TRW Space Technology Laboratories and TRW Computer. Among contracts received by TRW Semiconductor are an Air Force contract for development work on a sense amplifier and a contract from Litton for gates for the F-111B computer. TRW also is doing some IC work for the *Mauler* missile system.

A joint program with STL has led to the development of a capability of depositing thin-film cermet resistors on top of active silicon substrates. For TRW Computer, the company produced an integrated scratch pad memory containing about 60 components. In this case the proximity of devices is used to reduce propagation delays. The memory is presently being evaluated.

Company-funded research includes development of integrated forms of insulated-gate field-effect transistors and NPN-PNP transistors. A compatible NPN-PNP technique has been developed and the company is currently looking for a circuit vehicle to put it in.

Electronics Division of Space Technology Laboratories, Redondo Beach, Calif., initiated a program last year to provide a capability of systems use of IC's. Principal equipments that the division is microminiaturizing are receivers, satellite altitude control systems, telemetry and command equipment, programmers, and radar systems. STL developed a dot-component system for the *823 satellite,* but did not use it because of poor availability of parts and lack of multiple sources.

The company buys IC's from various companies, but works closely with TRW Semiconductor on research aspects of these devices.

During the last year they have had a $250,000 company-funded program to develop the vacuum-evaporation of cermet resistors on top of silicon chips.

STL is proposing IC processing equipment for *OGO* to provide an interface between about 20 experiments and the digital data handling system. STL is developing a classified military digital device with some 500 IC's. ■

Here's how Martin Company saves $16,000/year cleaning safety suits for TITAN II!

PROBLEM: It used to be an expensive and time-consuming job for Martin Company's Canaveral Division to clean these critical safety garments. The suits protect TITAN II launch-stand personnel from toxic propellants during fueling and countdown. They must be cleaned after each wearing for toxicity and sanitation reasons. Formerly, Martin did this laboriously by hand with detergents at $6.35 per suit.

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A Report on the DDR&E

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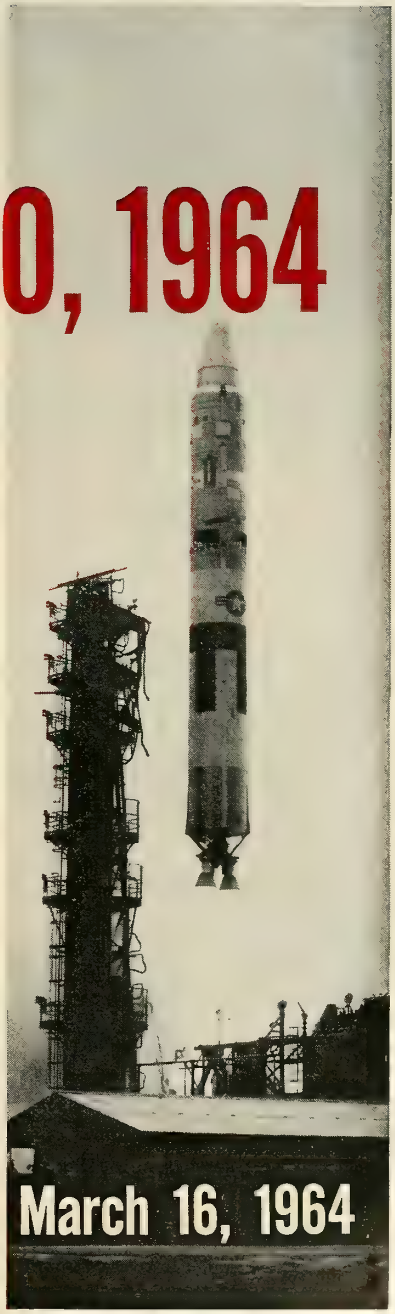

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Integrated Circuits Improving In Quality, Dropping in Cost

Answers to interconnection problems are developing rapidly; new circuit theory will be needed; a step-by-step assessment

BETTER PACKAGING and interconnection of microelectronic circuits will appear during 1964, together with a lowering of the cost of custom integrated circuits.

Main problems in interconnection occur in large data-processing computers. A solution can be expected in the development of larger arrays of devices within a single chip, mounting numbers of chips in one package, and development of a reliable means of connecting these chips to deposited arrays of interconnections.

This interconnection technique will reduce the present high cost of mechanical assembly, and will probably be carried out by systems manufacturers rather than by semiconductor manufacturers. In this way the systems manufacturer gains more flexibility in designing his own circuits, without the heavy cost penalty now associated with custom design in the integrated-circuit technique.

Semiconductor manufacturers now offer diffused chips containing up to 69 devices that can be connected in a variety of ways by a vacuum-deposited aluminum pattern. Customizing depends on changing one mask, which is fairly inexpensive. As stable high-resistance films become more readily available, a greater degree of customizing will become available, by variations of two masks. New vacuum-chamber techniques will reduce the cost of the additional mask.

Design of interconnections for present multiple-option chips is becoming a computer routine. Computer use will become essential for maximum benefit to be achieved from two depositions on complex multiple-option chips of the future, which will contain several hundred components.

An increase in the number of components will also increase the complexity of their interactions. Tape-controlled machines are being developed for mask production.

As circuits get more complex, a new circuit theory will be required, with replacement of conventional concepts of inductance, capacitance and resistance by new concepts of systems that are easier to analyze.

Conventional concepts are already being challenged in integrated circuit design. If a capacitor in a circuit is for rapid-charge transfer, it may be replaced by a transistor. If it is part of a low-frequency selective network, it might be replaced by a thermal network.

Progress in complexity within a single block of material has been steady. Each step has, however, yielded its own technology that finds application somewhere in the hierarchy of systems manufacturing.

- **Cordwood Stacking**—First step in miniaturization—reduction in space between axial-lead components by stacking them "cordwood" fashion between parallel circuit-boards—is still being improved. Welding is being used increasingly, either by means of a nickel wire grid, nickel ribbon system, preformed circuits with weldable tabs, or chemically etched circuit patterns.

Difficulties have included multiplicity of weld schedules, the need to orient each weld junction, and operator errors in routing nickel ribbon.

To overcome these, a tubelet interconnect system called "Polyweld" developed by U.S. Engineering Co. provides pre-established circuitry that has a weldable nickel tube at each terminal pad. This is grown by electroforming at the same time as the circuitry.

The technique is being used in such systems as APN-141 and APN-150 radio altimeters, the gyro platform of the TFX inertial guidance system, and the missile-borne computer for the TFX's *Phoenix* missile. Multilayer Polyweld systems use the clearance hole technique.

- **Microcircuit modules**—Another approach that started at this level of microminiaturization is the Micro-Module technique, where wafer-shaped components are stacked vertically. Mechanical support and electrical interconnection is provided by riser wires, previously soldered into notches in the wafer edges, but now welded to deposited tabs, without notches.

Each wafer may contain up to four discrete components, or (in the Enhanced Micro-Circuit Module program) a thin-film circuit, an integrated circuit, or some combination of these.

The Army Electronic Research and Development Laboratory, developer of this approach, says the assemblies can be mounted in hermetically sealed cans, so that the integrated circuits do not require packaging.

- **Optical connections**—Use of a light beam instead of a metal conductor has been suggested as an alternative means of connecting circuits. The most likely application is in stacked logic planes, without the use of fiberoptics interconnectors. Work is continuing on fiberoptics systems, however, and there are reports of improvements in coupling techniques.

- **Pellet components**—The second step in miniaturization—size reduction of discrete components—is also being actively pursued, and circuits using these components are in the TFX, *Polaris* flight-test equipment, and a number of diode arrays used by different computer manufacturers.

The Hughes Aircraft Co. approach to this technique, called "Microseal," uses a flat circuit board ("Swiss cheese") in which "pellet" or "dot" components are imbedded. Component connections are made by a combination of electroless and electrolytic plating on both surfaces of the board.

Hughes is aiming to bring down the cost of pellet diodes and transistors by use of glass instead of ceramic encapsulation. Microseal transistors now cost between $1 and $15 in lots of 1,000.

The imbedded pellet approach has the advantage of parameter selection with the interconnection features of integrated circuits. Hughes offers to set systems manufacturers up in the manufacture of the "Swiss cheese" circuit boards, so that they can retain the business of circuit production.

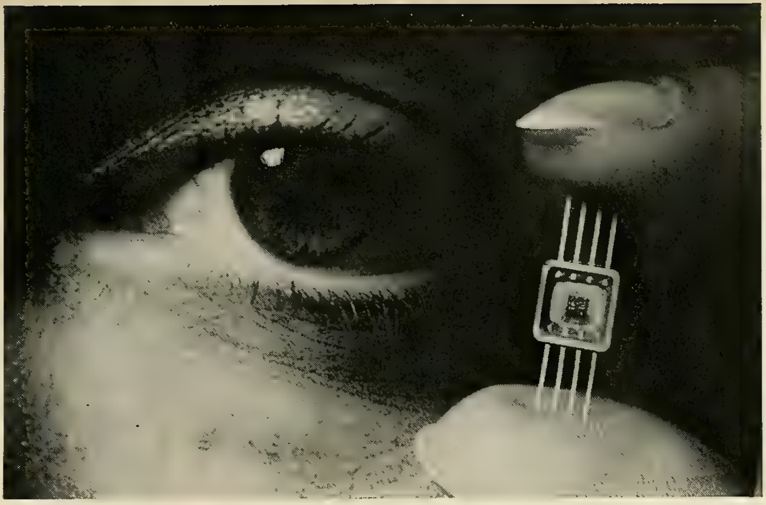
Cornell Aeronautical Laboratory has proposed sandwiching pellet components between plated elements on a non-rigid substrate on the grounds that flexure of rigid boards can lead to open circuits if the sandwich technique is not used.

- **Thin-film passives**—Further up the scale of integration is attaching or imbedding active devices into thin-film passive networks. A technique developed by Intellux, Inc., for flip-flops, multi-vibrators and gates uses conventional TO-5 can transistors that fit into a header. The thin-film circuit is connected to pads on the header by induction soldering. The leads from the TO-5 can are welded to wire risers from the pads.

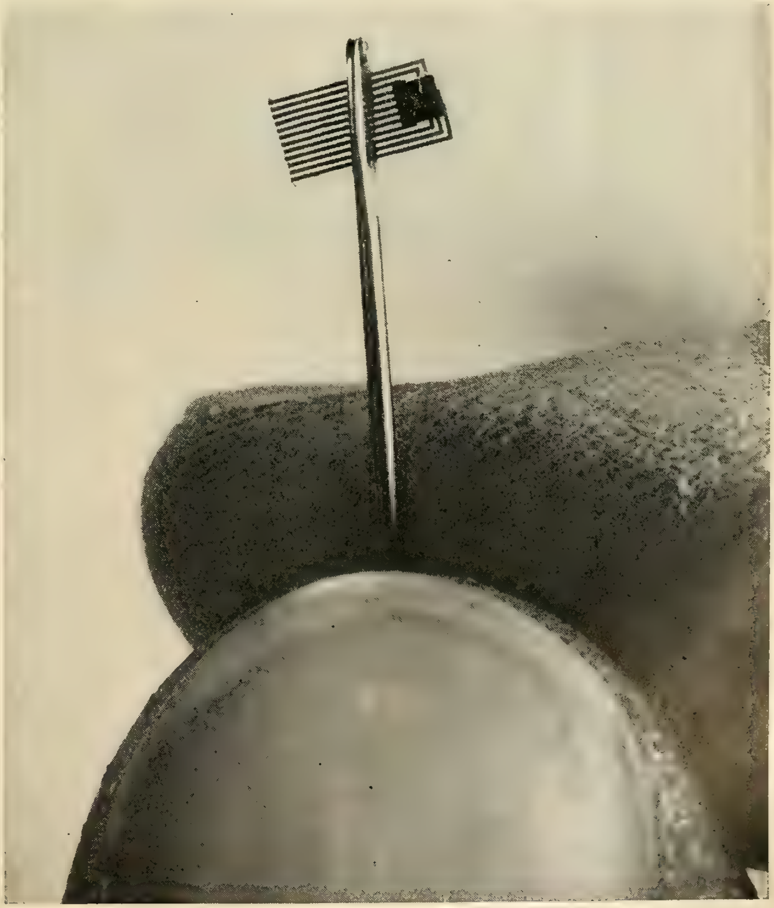
The Intellux passive circuit chips are formed from tin oxide, 2,500 Å thick, pyrolytically deposited on glass and hermetically sealed with a fused glass superstrate. Circuits of this type are being used at the Pacific Missile Range, Atomic Energy Commission, and by a number of systems companies that do not have government-funded contracts.

A widely used form of assembly is attachment of active devices directly to a thin-film network deposited on a ceramic or glass substrate. Attachment can be done by soldering, thermocompression bonding, or welding.

Circuits of this type, in which the resistive elements and conductors are applied by a screen process and fired on, are produced by North American



ABOVE: Tiny functional electronic blocks manufactured by Westinghouse Molecular Electronics Div. Entire electronic circuit, equivalent to nearly 50 separate components, is contained in silicon chip (dark spot in center). BELOW: Micro cable developed at Cornell Aeronautical Laboratory fits easily through eye of needle.



Aviation's Autonetics Div. for the inertial measuring unit of the *Improved Minuteman* guidance system. These high-temperature arrays are produced on an automatic line.

Microlectron Inc., producer of circuits by the firing process, suggests that the cost of this type of flat-plate module is often the same as the cost of an equivalent printed circuit board in quantities above 1,000.

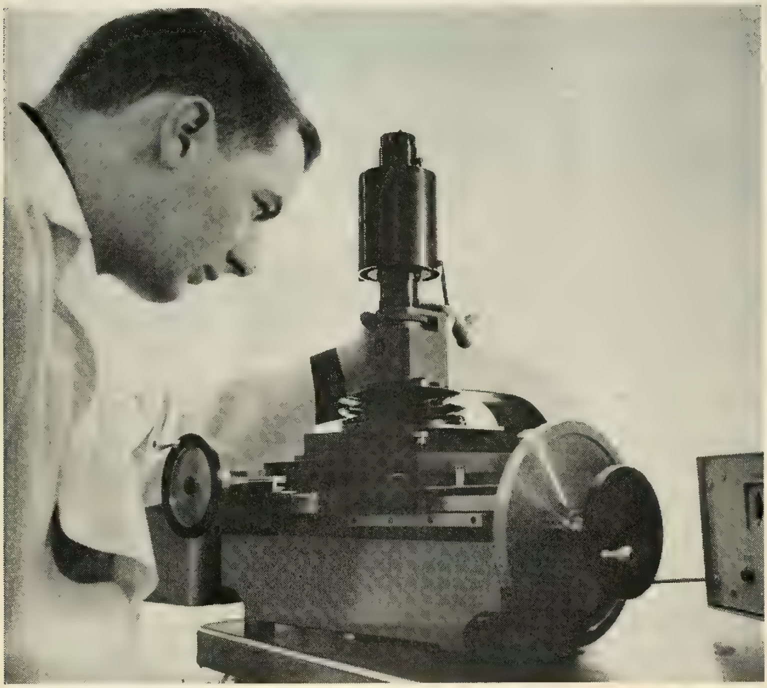
Lockheed Missiles & Space Company produces titanium passive circuits on a ceramic substrate by placing the substrate in a metalizing salt in a 500°C furnace. The whole substrate becomes covered with a 5,000-Angstrom film of titanium, which subsequently can be etched to desired resistor or capacitor patterns and interconnected by deposited copper.

A dielectric is formed by anodizing the titanium to titanium dioxide. These circuits are highly resistant to radiation.

Many companies are producing vacuum-evaporated thin-film passive networks with directly attached components. Hughes expects to be ready to produce thin-film passive circuits of this type with Microseal diodes and transistors by the middle of this year. General Dynamics/Astronautics has a maskless process for vacuum-deposited circuits. Elimination of masks, mask-holding equipment, and related fixtures is expected to reduce costs.

Aerojet-General Corp. has developed a method of bonding unencapsulated transistor chips into a glass or ceramic substrate, then vacuum-depositing a thin-film network on the substrate. The company has also deposited gold, copper and chromium thin films on 0.001-in. Mylar substrates, pre-coated with silicon monoxide to prevent outgassing.

Collins Radio Co. reports that no more problems have been encountered with these thin-film systems than have been ecountered with conventional printed circuit boards. The company is studying thin-film circuits that will cost half as much as the conventional circuits they replace.



MANN TYPE 1080 Photorepeater is continuous-process photomask system capable of producing original glass-plate masks to an accuracy of ±5 x 10^{-7} in. A row of up to 99 programmed exposures can be completed in 25 seconds.

Halex, Inc., a company specializing in production of thin-film vacuum-evaporated circuits, points out that one of the problems firms entering this field will encounter is a shortage of vacuum technicians. But a marked trend toward automation may relieve this situation. Halex has done some work on interconnection of discrete components by vapor deposition and says the process appears to have considerable merit.

Daven Co. is using a maser optics laser to adjust thin-film resistors with an accuracy of one part in 2,000.

Continuous vacuum furnaces have been built at IBM and Western Electric Co., with a promise of very high volume production. Motorola Inc. has built a non-continuous furnace with automatic features that greatly reduce operator variations in the final product. Most difficult problem to be overcome is adhering to scheduled evaporation rates.

- **Metal oxide semiconductor**—Another refinement, this one from Radio Corp. of America, is the metal oxide semiconductor. It is basically a three-electrode version of the insulated-gate field-effect transistor, which uses an insulated control electrode, or gate. By varying the input voltage on the insulated gate, the device can be made to switch, amplify, or regulate its output in a manner analogous to a pentode vacuum tube.

Conducting paths are made in the silicon slice, leaving gaps where active elements are desired. The insulator is produced by oxidizing the silicon over these gaps. The metal control electrode is then deposited on top of the insulator.

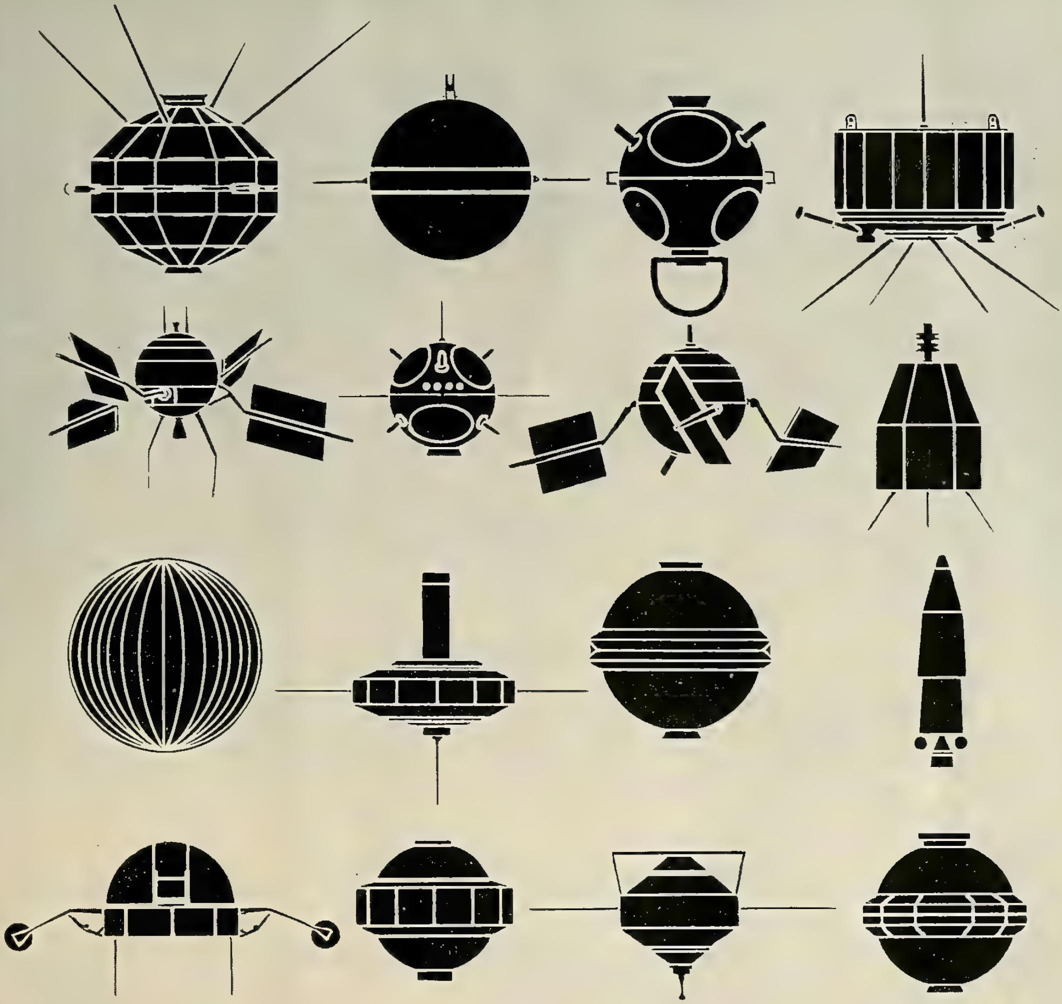
RCA scientists say they have refined this technique since it was initially developed so that 2,000 of these devices can be made on a single 1-in.-dia. silicon wafer. This provides a general-purpose array with reduced numbers of leads that can be made to perform any required digital function by simply adding one layer of wiring.

RCA has made both "n" and "p" devices, but is still working at combining these two elements in one process on a single wafer. Attempts also are under way to improve high-temperature stability, which RCA says is a matter of more process control. Processing of these devices is said to involve about one-third as many steps as bipolar transistor processing. RCA says it has obtained on-wafer yields of 97-98% without clean room conditions.

Power saving potential, the firm says, is exhibited by a 10^{-10} to 10^{-11} joules/bit switched rate, with power dissipated only during switching. RCA claims there is virtually no standby power required. The firm also claims these devices will offer an order of magnitude advance over bi-polar devices in radiation resistance and a threshold shift factor of 10 less over the same temperature range.

Research in active thin-film field-effect triodes is being carried on mainly with polycrystalline materials, primarily cadmium-sulfide and metal layers on a glass substrate. The firm sees good active thin-film devices as entirely possible within 2 to 3 years, with systems use 4 to 5 years in the future.

- **Reversing chips**—A contribution from General Electric that promises increased semiconductor reliability is the flip-chip technique. Silicon chips or functional blocks are, in essence, flipped from what has been the standard "face-up" position on a substrate, so that they



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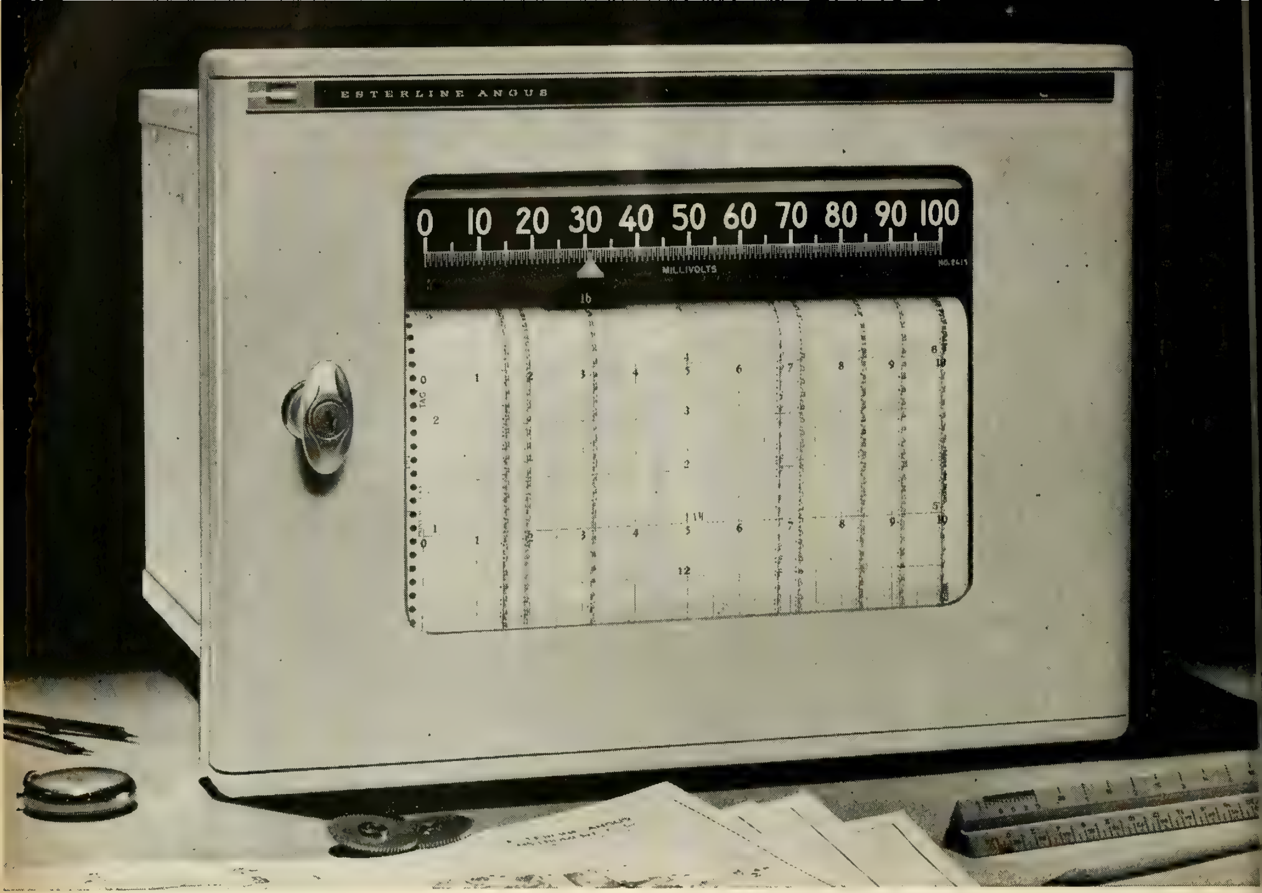

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are mounted working-face-down on an evaporated thin-film interconnection substrate.

Bonding the chip to the matching terminal pads of evaporated aluminum on the substrate permits elimination of the thermo-compression-bonded "flying leads." These have been a major source of reliability problems in planar semiconductor technology, cutting interface numbers to four, according to GE.

GE has done the face-down bonding with solder and welding techniques, but is most optimistic about ultrasonic welding. One of the objectives of current work is in-process repair of the flip-chip assembly. Chips reportedly have been bonded, removed from the assembly, and then rebonded.

About 15 to 20 functional blocks can be mounted on a ½ x 1-in. substrate, and about 30 to 40 can be mounted on a 1 x 1-in. substrate, both contained in a hermetic package. The main body of the package is a molded glass-mica frame with the upper and lower faces metalized and pre-tinned. Covers are metal and pre-tinned around the edges. Thirty-eight external leads are arranged along two sides of the package. In assembly, leads are first attached to pads on the substrate.

- **Integrated circuits**—Considerable improvement in integrated circuit production technology has marked the past year.

The precision of camera work has been increasing steadily. One firm says it is using two-micron design clearances (80 microinches) and claims a final-camera accuracy of 10 microinches. Another quotes 35 microinches as the total error across a two-inch wafer, through seven masks. Another has a multi-barrel final camera that has 25 microinches repeatability and 80 microinches absolute error.

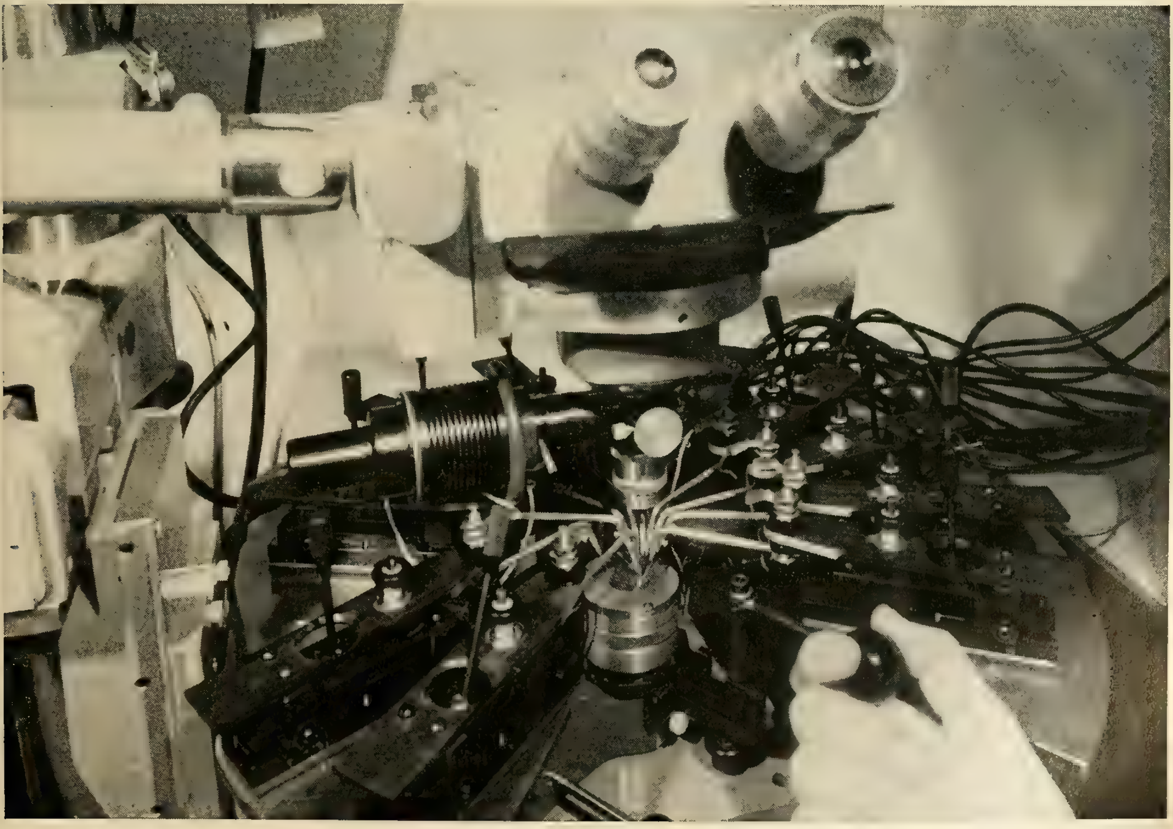
Two inches seems to be the maximum diameter over which resolution can be maintained. Final cameras have to be housed on shock-isolating bearings in clean rooms and can be tape-controlled when they are the step-and-repeat type. Camera prices can vary from $8,000 for an R&D machine to $100,000 for a production machine.

Little is heard about the alternative to step-and-repeat—the optical production of multiple images—except that IBM is said to be having problems attaining even resolution across the image plane while Ferranti, England, is said to have developed a production camera of this type.

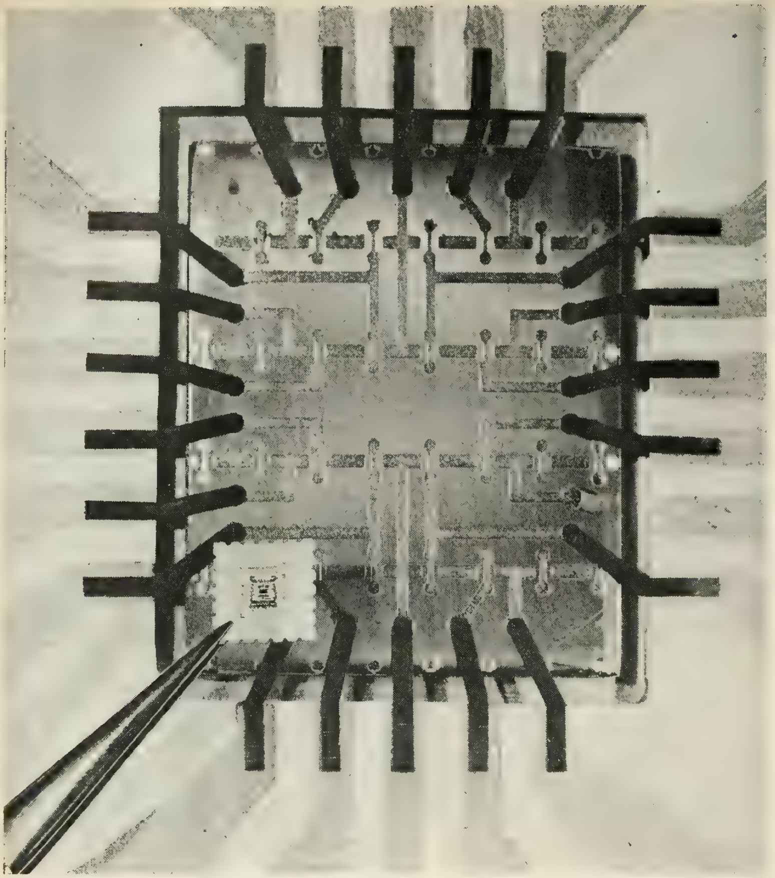
Integrated circuit firms would welcome something better than the Kodak high-definition plate, but nobody seems able to produce one. An alternative may be use of an electron beam or a laser to cut a mask pattern, but costs of such devices are far too high. Some progress has been made in electron-beam mask production for microwatt circuits. Six microns has been suggested as the shortest defined length that can be achieved with this technique.

A recently introduced instrument that promises to replace the step-and-repeat method comes from David W. Mann Co., a division of Geophysics Corp. of America. The Type 1080 Photorepeater is said to be able to produce highly precise, low-cost photomasks for integrated circuits at the rate of two an hour. The unit is seven times faster than existing photorepeaters, according to its developer, and produces original glass plate masks, each with an accuracy of ± 50 x 10^{-6} in. for all pattern elements.

Up to 99 programmed exposures may be made in 25 seconds with the Type 1080 on a continuously moving plate.



EVALUATION AND TEST INSTRUMENTS often are custom-designed for specific jobs. This 10-point probe is one of a series especially adapted for evaluating Motorola monolithic MECL circuits. Associated equipment provides semiautomated testing capability.



RCA'S COMPLEX "LOGIC" CIRCUIT for computers, shown in ceramic package held by tweezers, is contrasted with large mock-up revealing circuit's fine detail. Unit is made from single chip of silicon with 16 insulated-gate, field-effect transistors.

The final original mask, comprising 30 to 50 rows of complex patterns on a standard-size high-resolution plate (2 x 2 x 0.060 in.), can be completed in 30 minutes.

In diffusion technology, the trend to closer temperature control of furnaces is noticeable: ± 0.5°C at 1,300°C is a common specification. Hughes reports a big improvement in yield when going to ± 0.25°C, and Fairchild Semiconductor Div., Fairchild Camera and Instrument Corp. is looking into the possibilities of even tighter temperature control. Also noticeable is the increased use of automatic controls in the gas systems for diffusion furnaces.

Epitaxial techniques have continued to improve, though a number of technical problems have to be overcome before they can be used as easily and cheaply as diffusion. But epitaxy will eventually begin to take over some of the jobs now done by diffusion. The chief problem is growing epitaxial regions in a controlled geometry. Slightly polycrystalline growth occurs near the edges of defined regions, giving undesired electrical characteristics.

An alternative to masking and subsequent selective diffusion is activation of a semiconductor surface in a predetermined pattern by an electron beam or ion beam. An appropriate gas or vapor would have been let into such an electron- or ion-beam reactor to modify the semi-conductor characteristics along the activated region. The beam would also be used for readout and as a mechanical milling device. Chief problem is crystal damage at the point of beam impact.

Forming semiconductor junctions by ion-implantation looks even more difficult.

Relatively few of a great number of materials-processing research techniques become production technology.

Connection techniques to the integrated circuit chip have changed very little over the past year. The realization has grown that this problem, the packaging problem and the problem of connecting chips or packages are all closely related and need a unified approach if the optimum solution is to be found.

Techniques for depositing resistors and capacitors on diffused active substrates are being pushed hard. Motorola has delivered circuits of this type, but not on any large contracts.

TRW Semiconductor has developed a process for depositing cermet resistors. Electro-Optical Systems, Inc., has been working with tin oxide deposition and has produced a three-transistor gate circuit by this means. Hughes has developed several logic circuits using deposited nichrome resistors, which will be marketed in the first half of this year. The company is working on a multiple-source chamber to deposit both aluminum and nichrome, reducing the processing costs incurred by an extra deposition step.

The advantage of using nichrome deposition is that such a resistor will only change by 5 to 8% of its value over a −65° to +125°C temperature range. A diffused resistor will change its value by about 50 to 60%.

For resistors over about 100 kilohms, a higher resistance material than nichrome is needed. The problem with high-resistance materials has been ensuring sufficient stability, but this seems to have been overcome. Cermet resistors are being used in an integrated-circuit pre-amplifier in the *Phoenix* missile.

High values of deposited resistors are needed for the production of micro-watt circuits—of great value in space applications. As well as improved temperature performance, the deposited resistor has better frequency performance, because its distributed capacitance is lower. Better transistors can be produced because transistor and resistor fabrication are independent.

The chief problems are achieving a uniform pinhole-free oxide on which to carry out deposition, and achieving accurate deposition. This type of deposited resistor cannot now be trimmed without damaging the active circuit. A high resistor yield is essential or loss of active circuits becomes prohibitively expensive. Achieving uniform deposition requires a very clean substrate that must be obtained without damaging the active devices.

Microwatt integrated circuits also call for the very best mask techniques so that transistors that have sufficient current gain at microampere currents can be produced.

- **Multi-chip hybrids**—Intermediate between the complete monolithic integrated circuit and conventional methods of discrete assembly is the technique of mounting unencapsulated discrete components on a ceramic header and interconnecting them by deposited patterns or bonded wires.

These circuits are available in TO-5 cans or in flat packs. High-frequency performance often improves with this technique, which also provides lower tooling costs and goes into the production stage faster than monolithic circuits.

Motorola is producing about 20 to 25 different circuits of this type, in quantities up to 100, each month. Average price of a circuit is $100. Five or six circuits can be stacked in a TO-5 can.

Research into development of active thin-film devices continues to be widely discussed. Many systems manufacturers with a capability to evaporate thin-film passive components single out deposition of thin film active components as the ultimate aim of their research. Chief reasons given reflect an assumption that active thin films will have the same characteristics as passive thin films: low susceptibility to radiation damage, potentially greater packing densities, lower cost for small quantities, better yields and tighter tolerances.

Of these, low susceptibility to radiation damage is the most likely to be realized, while tighter tolerances and higher yields are least likely in the near future. Development of useful semiconductor devices has been a history of avoiding surface effects, because of their uncontrollable nature. Despite recent improvement, the biggest problem in active thin films is still achieving reproducibility and good characteristics.

Introduction of thin-film active devices into systems is almost always pegged at between three and five years in the future, with cadmium sulphide field effect devices most often mentioned as likely to come out of the lab first. Cryogenic and magnetic thin-film devices also look like early starters.

Though some research continues with single crystal materials, most is in polycrystalline approaches to development of thin-film field-effect, space-charge limited, or "hot electron" devices. Engineers prefer polycrystals because of their improved radiation resistance and easier processing, compared with single crystals.

- **Micron-size logic**—A fabrication technology that promises devices with all of the advantages of thin-film active devices without use of semiconductors is being investigated at Stanford Research Institute. Extremely high packing densities are predicted—100 billion devices per cubic inch.

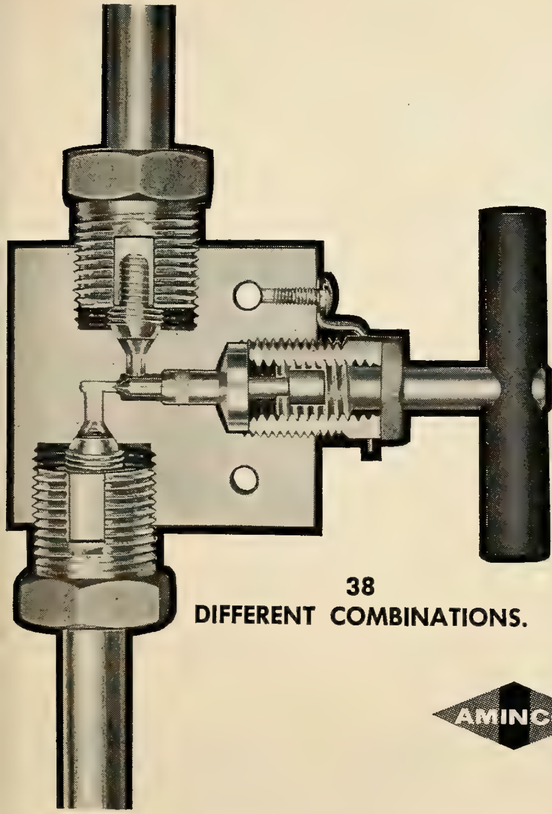
Only radiation-resistant refractory materials are used—molybdenum on aluminum oxide. Operating temperatures can reach 800°C. Switching times are too short to be measured but are calculated as 0.01 nanosecond. Light detection and generation have been demonstrated. Micron-size filters for frequencies between 1 and 60 mc, with Q's of 1,000 can be made.

Heart of the technique is metal deposition by activating a coated substrate by an electron beam, at pressures of 10^{-12} torr. Processes in the vacuum chamber are monitored by means of the electron beam and by an RF quadrupole mass spectrometer sensitive to 10^{-14} torr partial pressures.

For satisfactory production of devices, an electron-optical system must be fabricated that is mechanically accurate to two microinches over a length of 19 inches. Using this equipment, tunnel-effect vacuum tetrodes have been produced that have power gains of one million and a 50v optimum operating voltage. Current swing for a 2 to 50v change is from 10^{-14} amp to 10^{-4} amp.

One of the advantages of the technique is that the devices are self-forming—very much as electrolytic capacitors are. The surface is coated with metal chloride and traversed in the required pattern by the electron beam. Those that are too sharp dull back. After the array is formed, it is heated to drive away the activation.

SRI has investigated the possible use of dielectric devices instead of pure vacuum devices. Findings are that on



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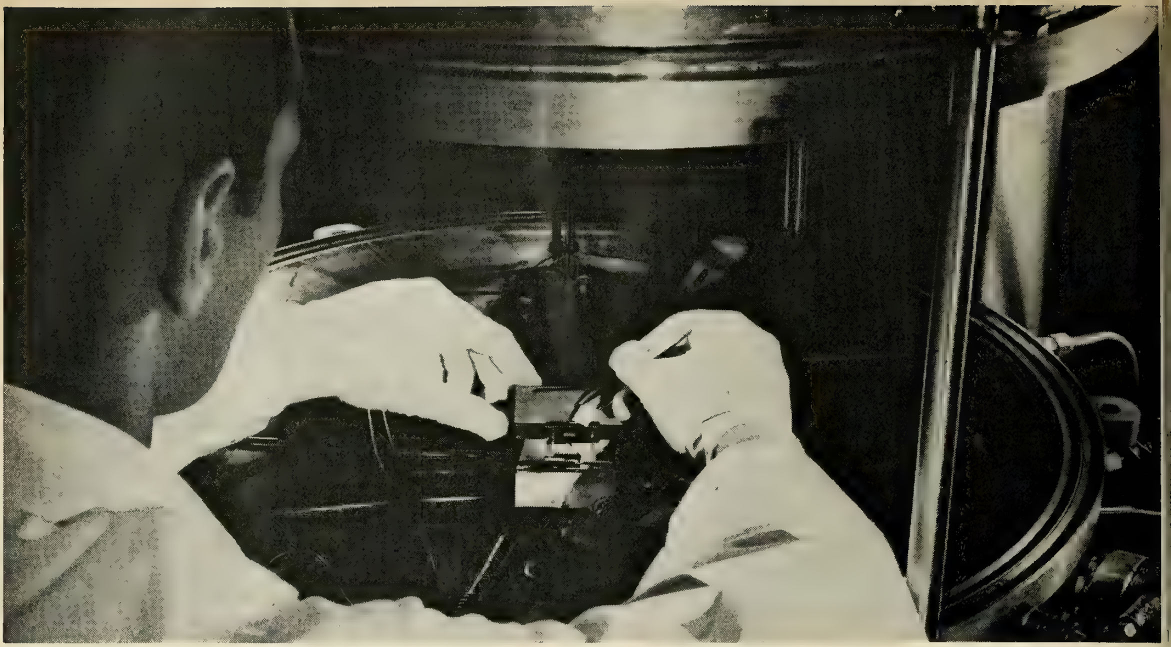

SYLVANIA TECHNICIAN inserts ceramic substrates in a vacuum evaporator for electron beam deposition of thin film. Many manufacturers are attaching active devices directly to a thin-film network deposited on such substrates.

this size scale a dielectric can exhibit a tremendous variety of electronic effects, but not reproducibly. An all-vacuum system is preferred.

Interconnection and memory functions would be provided by electron beams guided by an electric field. Stability of figure-of-eight electron orbits for memory has been demonstrated with an analog device. In effect, memory would be related to a vector coordinate system instead of a space coordinate system.

An input gate has been fabricated, using series connected triodes. This is a 1-milliwatt device, 100 billion of which would fit into one cubic inch. If 100,000 of these were switching together in the center of the cube at 10^{15} bits/sec., the internal temperature would rise to 800°C, which is the highest temperature planned for the system.

Progress in this technology has been very good over years that have been critical to its feasibility. Building of instruments and component exploration has taken about three years.

Within another three years, these devices will probably be shown cooperating in small groups as a basic demonstration of their capabilities. Aim of the technology is to lift present computer limits of about 10^7 active devices up to 10^{11} devices and higher to give intelligence systems capabilities equal to or exceeding that of the brain.

The technology is significant both from the basic simplicity and stability of the materials it uses, and in the short lead time it offers between laboratory and factory production. It also uses to great advantage the various technologies suggested for integrated circuits—electron beam techniques instead of photoetching, thin-film deposition instead of diffusion, ultra-high vacuum. Further, a wholly new approach to interconnection has been taken.

- **Automation**—There has been a general increase in automatic techniques in all stages up to the breaking out of diffused chips, the aim being to eliminate operator variations in the process. Clean-room techniques are also being used increasingly.

Automatic assembly equipment is making its appearance, together with improved handling techniques. Fairchild is moving away from its policy of using only very simple chip-processing equipment, Motorola has developed an effective jig for transporting groups of devices through mechanical assembly.

Most manufacturers are against moving toward full-scale automation because new technological developments can render a costly but inflexible automatic line obsolete. Hand labor may be additionally reduced soon, however, with development of new techniques of lead connection.

- **Packaging and interconnection**—For military computers with about 5,000 integrated circuits per machine, the present technique of mounting flat packs to multiple-layer printed circuit boards is adequate, but more efficient packing schemes will be produced that are less wasteful of volume. Their reliability will have to be evaluated before they can replace present methods.

Flat packs have given handling problems, and many manufacturers are suggesting jigs to hold the circuits during incoming inspection and testing.

The packaging problem is most acutely felt in the large data-processing computer, in which interconnection volume far exceeds the volume of active elements. The solution here will be production of more complex chips, and mounting of large numbers of chips over deposited metal patterns within a single sealed package.

A number of flat packages are available and the trend is toward ease of assembly, simplicity, and lower cost. Use of a metal case has been avoided in recently announced packages, because of possible electric shorts between leads and case and the difficulty of obtaining a hermetic seal.

Motorola is using a ceramic pack with castellated walls that act as a jig for the external leads, formed from a single sheet of metal. A ceramic lid completes the package. Lid and leads are sealed in paraceram glass.

Signetics Corp. uses a hard glass package in which the main body and lead assembly are fused into a single unit, as in the TO-5 can. A pocket deep enough to expose the tips of the leads is then formed, one of the leads being a pad to which the die is attached. A kovar lid is then fused to the top of the package to seal it.

Siliconix, Inc., has developed a flat pack in which the die is fused within glass between two ceramic plates, and is currently evaluating the technique for reliability. Several other companies are working on glass passivation by pyrolitic decomposition—a technique that has already been applied to diodes.

Molecular packaging of integrated circuits has been suggested by Microsemiconductor Corp. This would involve the same process the company uses for diodes it supplies to the *Improved Minuteman* program.

The oxide layer on silicon is made hydrophobic by bonding an esteril layer of molecular thickness to it. Problems are encountered, however, in obtaining a high enough yield of fully surface-stabilized devices by this technique.

To avoid expensive hand labor in lead attachment processes for present flat-packs, Motorola is investigating a technique whereby the leads through the wall of the pack rest on the terminal pads on the die and are brazed directly in place in a low-temperature furnace.

An alternative approach being investigated by a number of companies is to deposit interconnecting leads on a substrate, turn the die over, and bond the terminal pads directly to the substrate. A third approach, which has the advantage that die bonding and electrical connection functions are separated, is imbedding the die in a substrate and deposition of a conductor network over the substrate and die.

These techniques have the advantage of allowing a number of dice to be mounted on a common substrate within a common package.

General Electric has mounted 24 circuits within a 1-in. by 1-in. package by the flip-over technique. Honeywell has produced a binary adder circuit with some 300 transistors and 250 resistors (25 integrated circuits) on a single substrate. Connections between circuits are continuous with no interface material changes.

Cornell Aeronautical Laboratory has developed a technique for mounting integrated circuits on Mylar tape to improve present packing densities 80 times.

A micro cable is electroplated on a Mylar carrier sheet and then transferred to a pressure-sensitive, Mylar-backed adhesive tape 0.001 in. thick. The integrated circuit is then aligned with the cable ends, and the connections formed. Mylar tape is also used to encapsulate the circuit.

Certain manufacturers, such as Motorola and General Micro-electronics, stress the need for a custom packaging capability to meet customers' requirements.

Hamilton Standard division of United Aircraft Corp. is developing an electron-beam welding technique for interconnecting integrated circuit flat packs on matrices of metallized ceramic boards.

- **Circuit boards**—Multilayer circuit boards with plated through connections or clearance holes are being widely used for connecting flat packages. Intellux is producing thin-film multi-layer boards by a deposition process that not only provides solid metal jointless connections from board to board, but also gives jointless weld posts at the edge of the boards.

The deposited posts are revealed when the board around them is etched away. They are welded to vertical risers that interconnect successive layers of multilayer boards.

Other techniques for forming connections to integrated circuit packages include the wire-wrap technique, the "weld post" concept developed by Sippican Corp., the "Fusicon" technique developed by Photocircuits Corp. and

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use of etched nickel-Mylar layers.

Xerox Corp. and P. R. Mallory & Co., Inc., are cooperating to develop multilayer boards with resistive, conductive and capacitive layers, using xerography to control circuit layout.

Increasing complexity of multilayer boards is leading to a demand for computer routines to design them.

- **Testing**—Increased complexity in integrated circuits has led to development of new testing equipment, for use both at the slice level and at the finished package level. Motorola performs a 100% probe of slices with a high-speed automatic indexing probe with go/no-go electronics. This provides rapid feedback of quality of diffusion processing and prevents assembly of defective devices. There is a 90% probability that a device passing this tester will also pass the final package tester.

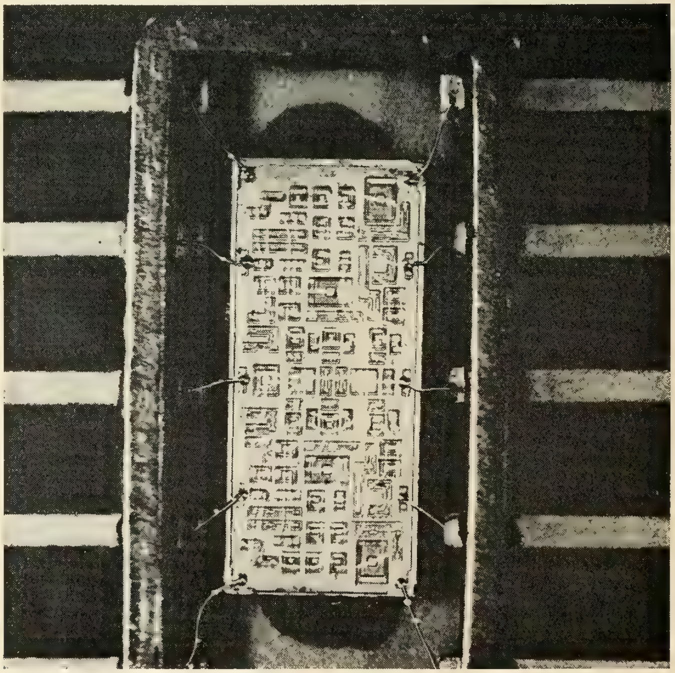
The Motorola tester has 12 needle probes, and carries out 51 tests on T^2L circuits in less than a second.

Final testing at Motorola is by means of a punched-tape program tester that provides a visual readout and also logs circuit parameters on tape. A variable program machine is needed for the large number of different circuits produced—up to 100 per month. Thirty to 40 parameters are tested in 0.5 sec.

Automatic testers for integrated circuits are marketed by Fairchild and Texas Instruments, Inc., (M/R, Sept. 16, p. 36), and by General Microelectronics.

- **Yield**—Yields in integrated circuits are now above 10% in some companies. Motorola is claiming a 50% yield on certain simple circuits. Yield depends on correct mask design, good definition masks, good photoresist technology, good diffusion technology and good mechanical handling and packaging techniques.

- **Reliability**—Tests up to July 12, 1963, on Intellux thin-film modules gave a predicted reliability at the 2% level of 2.78 x 10^{-5} probability of failure. Tests on Series 51 Texas Instruments integrated circuits during 1962 (nearly 4-million circuit hours) showed a failure rate of 0.05% per 1,000 hours with 60% confidence. Tests on Fairchild Micrologic elements up to February, 1963, (over 15 million circuit hours) showed a failure rate of 0.044% per 1,000 hours at 90% confidence level. Signectics had accumulated 2.6-million circuit test hours by August, 1963, and says that the circuits tested are capable of demonstrating a failure rate of better than 0.01% per 1,000



TI SERIES 53. Newest of the Texas Instruments, Inc., integrated circuits is this complex package employing up to 69 components per slice. Growing complexity of integrated circuits has created a demand for new testing equipment. TI is one of the leading manufacturers of automatic integrated circuit testers.

hours at standard use conditions.

In general, integrated circuit manufacturers believe that their circuits have reached the reliability of transistors.

- **Design or manufacturing limitations**—A basic limitation in integrated circuits is the interaction between components and the substrate. Signetics claims to have discovered a technique that does away with the use of reverse-biased diodes to achieve isolation, but has not revealed details other than to say that a new approach to fabrication that permits much more complex junction structures is involved.

Autonetics has announced techniques for growing single-crystal silicon on sapphire or polycrystalline silicon. By etching through to these substrates, high isolation between components is achieved.

Motorola points out that although it is investigating deposition of silicon on sapphire, this is an expensive substrate, and the production technology may be several years away. By present epitaxial techniques, junctions can be built with leakage currents of nano-amperes.

Hughes reports improved isolation by epitaxial fence structures, with 110-120v breakdown between components. Less than 90-v breakdown is considered a reject.

Degradation of high-frequency performance of linear integrated circuits generally restricts their operating frequency to below 200 mc. Use of multiple-chip circuits raises this limit to 300 mc.

The top collector contact configuration of the integrated transistor plays a large part in lowering the maximum operating frequency.

Other limits on performance are the size of integrated circuit capacitors, and their low Q when they are the junction type, and the poor tolerances on diffused resistors.

Intercoupling effects in integrated circuits can often make unstable a circuit that is stable in discrete form, calling for additional decoupling.

Present output of integrated linear power amplifiers is limited to about 1 watt. Ten watts has been produced in the laboratory and up to 50 watts is predicted with development of better junctions and packaging. Present video amplifiers can achieve about 20-db gain up to 10 mc. Both low-frequency and high-frequency response pose problems.

Absence of inductive elements imposes limitations on band-pass amplifier and oscillator design. Temperature variations and difficulties with PNP-NPN combinations cause rather poor drift figures in low-level dc amplifiers.

- **Radiation problems**—Main radiation hazards for integrated circuits are in the vicinity of nuclear weapons, or space-vehicle reactors, or as a result of repeated passage of a satellite through the Van Allen belt.

There are many projects underway to evaluate the effects of radiation on integrated circuits, but a heavy security curtain has been lowered. The reason for this is easily seen. Data that have been published suggest that interfering signals are generated in integrated circuits at gamma doses of 10^8 Roentgens/sec., and that some circuits cease to function after a neutron dose of 3×10^{14} neutrons/sq. cm.

Within one mile of a 20-megaton explosion the radiation will be between 10^7 and 10^8 Roentgens/sec., and the integrated neutron flux will be about 2×10^{13} neutrons/sq. cm. In combination these radiations would probably cause an integrated-circuit computer in a missile to malfunction. Higher radiation levels could probably be designed into a weapon of this yield, and it would have a greater effective range in free space. The radiation figures refer to surface weapons and were published by the AEC early in 1962. ■

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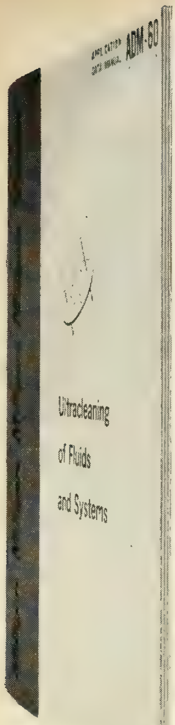

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$2,600,000—**AC Spark Plug Div. of General Motors Corp.,** Milwaukee, for *Titan II* gyros and accelerometers for the inertial guidance system.

$1,800,000—**Ralph M. Parsons Co.,** Los Angeles, for personnel subsystems, data and trainers for *Titan II* sites throughout the U.S.

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$226,000—**Martin Co.,** Baltimore, for refurbishment and depot maintenance on underground missile silos at Vandenberg AFB, Calif.

$140,000—**Cubic Corp.,** San Diego, for participation in the manufacture and installation of an UHF timing distribution system for Cape Kennedy and the Atlantic Missile Range.

$48,275—**Southwest Research Institute,** San Antonio, for fabrication and installation of airlocks, special door seals and inner shells in two environmental chambers at Brooks AFB, Tex.

ARMY

$484,753—**Raytheon Co.,** Andover, Mass., for *Hawk* missile assembly reconditioning.

$90,000—**United Aircraft Corp., Pratt & Whitney Div.,** East Hartford, Conn., for research and development on high-strength titanium alloy motor case for a solid propellant.

$61,000—**Martin Marietta Corp.,** Orlando, Fla. for reconditioning *Pershing* missile assemblies.

Sargent-Fletcher Co., El Monte, Calif., for construction of rocket motor fins for the Army Missile Command at Redstone Arsenal (undisclosed amount).

NAVY

$5,800,000—**Avco Corp.,** Richmond, Ind., for arming and fusing devices for *Polaris* missiles.

$2,000,000—**General Dynamics Corp.,** Pomona, Calif., for continued work on *Tartar* and *Terrier* missiles.

$1,400,000—**Interstate Electronics Corp.,** Anaheim, Calif., for *Polaris* missile test equipment.

$617,957—**Lasko Metal Products, Inc.,** West Chester, Pa., for a launcher rocket.

$135,455—**ITT Federal Laboratories,** Fort Wayne, Ind., for reworking and retrofit of target detecting devices for guided missiles.

$119,873—**American Astro Systems, Inc.,** El Monte, Calif., for fabrication and delivery of an environmental control system.

$57,303—**Dynatronics, Inc.,** Orlando, Fla., for modification of two telemetry antenna systems.

$27,989—**INCA Engineering Corp.,** Pasadena, Calif., for a study related to fabricating a rocket motor test stand.

$26,745—**Data-Control Systems, Inc.,** Los Angeles, for subcarrier discriminator assemblies.

Capehart Corp., Richmond Hill, N.Y., for provision of instruction, maintenance and repair for aerospace ground support equipment at eight air bases (undisclosed amount).

NASA

$1,900,000—**Northrop Corp., Nortronics Div.,** Needham, Mass., for a test device for simulating the launching phase of space flights.

$1,400,000—**Minneapolis-Honeywell Regulator Co.,** Wellesley Hills, Mass., for a computer to support *Saturn* booster production programs.

$830,903—**Martin Co.'s Denver Div.,** Colo., for development of two advanced pressure systems for cryogenic propulsion units for spacecraft.

$185,800—**American Machine and Foundry Co.,** Santa Barbara, Calif., for a research and development contract to study effects of impact on equipment of space pilots.

$175,000—**Ryan Aeronautical Co., Electronics Div.,** San Diego, for continued production of space altimeters for use on *Saturn* boosters.

$153,000—**Hayes International Corp.,** Birmingham, Ala., for instrumentation support devices.

$103,000—**Hallicrafters Co.,** Chicago, for data mode communication equipment to be designed and manufactured for use on the *Apollo* program.

$67,980—**Electromagnetic Research Corp.,** College Park, Md., for studies of ionspheric probing.

$63,550—**Thompson Ramo Wooldridge, Electromechanical Div.,** Cleveland, for a magnetic tape recording system.

$38,610—**Milgo Electronic Corp.,** Miami, Fla., for a digital tape recorder and tape transport.

$34,916—**Hardco Scientific Co.,** Cincinnati, for an electron microscope.

INDUSTRY

$1,500,000—**Consolidated Systems Corp.,** Monrovia, Calif., from **Electronic Instrumentation Div. of Lear Siegler, Inc.,** for three digital data acquisition, conversion and processing systems to be used in development testing of booster components for the *Saturn* and other lunar-shot programs.

$1,000,000—**Scientific Data Systems,** Santa Monica, Calif., from **Jet Propulsion Laboratory,** for three digital instrumentation systems which will verify operability of deep space probe tracking stations located around the world.

$800,000—**Consolidated Systems Corp.,** Monrovia, Calif., from **ARO, Inc.,** for the design, construction and installation of a universal data processing system at the Arnold Engineering Development Center.

$243,580—**Minneapolis-Honeywell Regulator Co.,** Milwaukee, from **Jet Propulsion Laboratory,** for a study of the requirements of a strapped-down miniature electrostatic gyroscope for use in advanced deep space probe attitude control and guidance systems.

$164,000—**Martin Co.,** Baltimore, from **Boeing Co.,** for flow control assemblies for the oxidizer tank outlets of the **Saturn V** launch vehicle.

REQUESTS FOR PROCUREMENTS

GENERAL PROCUREMENTS

Systems Engineering Group (RTD)
Wright-Patterson AFB, Ohio

Negotiations to be conducted with Explosiform, Inc., Park Forest, Ill., for continuation of contract AF33(65)-9631 for manufacturing technology related to low density explosive forming of typical aerospace metals to selected configurations. RFP 1412-RA. Note: For information only. RFP not available.

National Aeronautics and Space Administration
Manned Spacecraft Center
Gemini Test Operation Support Procurement Office
Houston 1, Tex.

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U.S. Army Missile Command
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Power supply, 1,000 volts, Federal Stock No. 1430-065-8677, Ordnance Part No. 9023901—26 each. IFB AMC(Z)-01-021-64-999B. Bid opening 2-26-64. Drawings and bid sets available from nearest procurement district.

—when and where—

FEBRUARY

International Conference on the Impact of Modern Physics on Materials, Sheraton Hotel, Philadelphia, Feb. 3-7.

Society of the Plastics Industry, Reinforced Plastics Division Conference, Edgewater Beach Hotel, Chicago, Feb. 4-6.

IEEE-MIL Fifth Winter Convention on Military Electronics, Ambassador Hotel, Los Angeles, Feb. 5-7.

American College of Radiology National Meeting, Tucson, Ariz., Feb. 5-8.

Institute on Information Storage and Retrieval, sponsored by American University, International Inn, Washington, D. C., Feb. 10-14.

Golden Gate Metals Conference, American Society for Metals, Fairmont Hotel, San Francisco, Feb. 13-15.

American Institute of Mining, Metallurgical and Petroleum Engineers Annual Meeting, Statler-Hilton and Astor Hotels, New York City, Feb. 16-20.

ASCE Transportation Engineering Conference, Netherlands Hilton Hotel, Cincinnati, Ohio, Feb. 17-21.

International Solid State Circuits Conference, sponsored by IEEE and the University of Pennsylvania, Sheraton Hotel and University of Pennsylvania, Philadelphia, Feb. 19-21.

Pricing and Negotiating Prime and Sub-Contracts in the Defense and Aerospace Industries Seminar, sponsored by the Contract Management Institute, Savoy-Hilton Hotel, New York City, Feb. 24-28.

Ninth Scintillation and Semiconductor Counter Symposium, sponsored by IEEE, AEC and NBS, Shoreham Hotel, Washington, D. C., Feb. 26-28.

MARCH

ASME Gas Turbine Conference and Products Show, Shamrock Hilton Hotel, Houston, Mar. 1-5.

Atmospheric Problems of Aerospace Vehicles, sponsored by FAA and AMS, National Aviation Facilities Experimental, Atlantic City, N. J., Mar. 2-5.

15th Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Penn-Sheraton Hotel, Pittsburgh, Mar. 2-6.

Fifth Symposium on Thermal Radiation of Solids, Sheraton-Palace Hotel, San Francisco, Calif., Mar. 4-6.

Southeastern Conference on Theoretical and Applied Mechanics, Georgia Institute of Technology, Atlanta, Mar. 5-6.

AIAA Aerodynamic Testing Conference, Marriott Twin Bridges Motor Hotel, Washington, D. C., Mar. 9-10.

National Association of Corrosion Engineers Annual Conference and Corrosion Show, Sherman Hotel, Chicago, Mar. 9-13.

Air Force Cambridge Research Laboratories Exploding Wire Conference, Kenmore Hotel, Boston, Mar. 10-12.

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Good for Your System

WE DEVOTE a major part of this issue of MISSILES AND ROCKETS to a special report on the fast-growing field of microelectronics. We hope it will be read with interest, not only by those directly involved but by others on the systems team who will be affected by this new technology.

One of the brakes on wider use of integrated circuitry is a misunderstanding, and indeed antipathy, on the part of some electronics systems engineers. There is no question that microelectronics is pushing component manufacturers toward systems design, a fact that has put a few noses out of joint. But the systems engineer who will benefit most from microelectronics is the one who concerns himself not with what is happening to his design prerogatives, but with what microelectronics can do for his system.

Of the importance of microelectronics, there is no doubt. Texas Instruments suggests that 75 percent of all military circuits may be microelectronic by 1972. This means a market that may reach $500 million annually by that time, compared to $60 to $70 million now.

It means also that a few more noses will be pushed out of joint before that figure is reached. But for the most part, the microelectronic manufacturers are not trying to move into the systems business.

Take one of the major problems still remaining in microelectronics—that of interconnecting devices for really large computers. Its solution is being hampered by the reluctance of the microelectronics firms to further invade the systems field, and by the uncertainty on the part of their customers as to who really should do the job.

The general manager of Motorola's Semiconductor Division, Dr. Lester Hogan, puts the problem this way: "Once I start connecting circuits together, I'm in the equipment business. I don't want to be in the equipment business. I can be more successful out of it."

As he sees it, the job of the microelectronics firms is to help the systems manufacturer find a solution to the interconnection problem, not to go into the interconnection business themselves.

Another question is the impact of microelectronics on ground-support equipment. It will be considerable, but the exact extent has yet to be measured.

The value of long-range market and technology studies of microelectronics to date also is a source of debate within the industry. A review of these surveys shows not too great a disparity concerning market growth and the rate at which it will be achieved. The independent studies made thus far that have gained widest recognition include those made by the Stanford Research Institute, Arthur D. Little Co., and a recently published report by Integrated Circuits Associates, a company name taken for the marketing of a report published last September by a group of Harvard Graduate School of Business students. There have been some company forecasts published, such as the one by Sprague Electric, which have also been placed alongside the independent non-manufacturers in an attempt to get a fix on the market.

The SRI, ADL, Harvard and Sprague studies bracket an annual sales picture roughly between $500 and $900 million a year by 1972. Some top manufacturers already feel these estimates are conservative, predicting several hundred million dollars in sales within four years for computer logic alone.

However, ADL warns that some published sales figures are misleading due to confusion of component sales with circuit sales, and projection of microcircuit-based equipment sales rather than just circuit sales. "We expect the microcircuit market will be several hundred million a decade from now. People who see a billion dollars probably mean systems, or equipment containing a large share of microcircuitry."

The citing of various IC production yield rates in industry-wide reports or by individual manufacturers should also be treated with caution. Generally, reports of yield are meaningless unless a lot of data concerning circuit complexities and production environments are included. Suffice it to say that production yields of integrated circuits are poor, and that the bulk of research into process control and material is aimed at improving this situation.

With recent improvements in SIC epitaxial techniques and the widespread effort to develop active elements compatible with thin-film processes, yield rates are apt to increase substantially within the next two years.

A Westinghouse expert points out, however, that a yield of 35% overall might well prove to be a limit for many years to come.

IT IS GENERALLY agreed that to date there is no one approach to integrated circuits that looks best for the multitude of requirements. Pure thin-film circuits, if and when they evolve, may prove the panacea, but the economies and performance trade-offs will have to be proved in production runs.

In the interim, the hybrid circuits, using a variety of substrates, are likely to provide the alternative to users who need higher speed and frequency than can generally be achieved with monolithic silicon.

These are a few of the problems still to be answered before microelectronics achieves its full growth. But solutions are in sight—and the payoff will be significant for those firms who gambled on acceptance of this new technology.

William J. Coughlin

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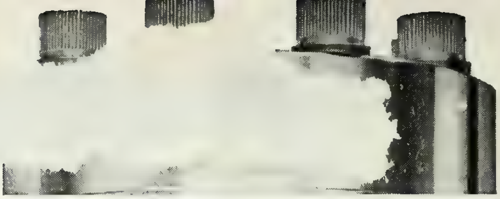

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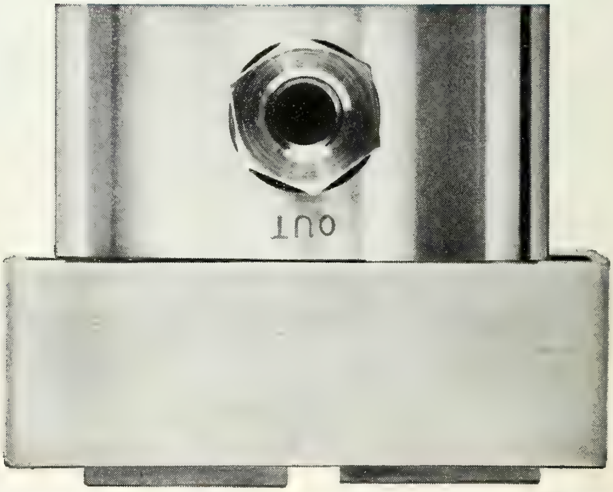

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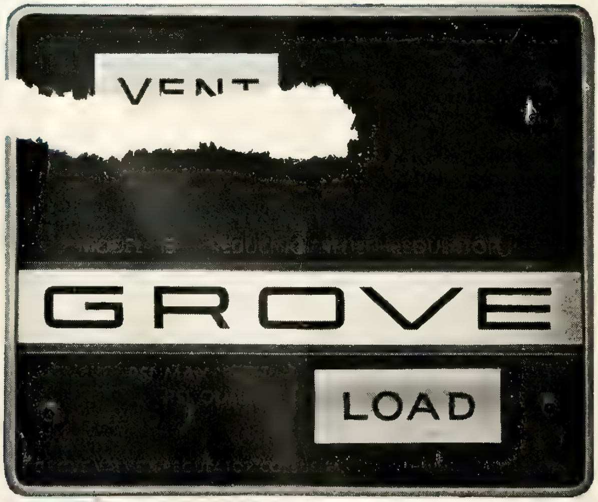

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Nuclear Engine Fight Looms

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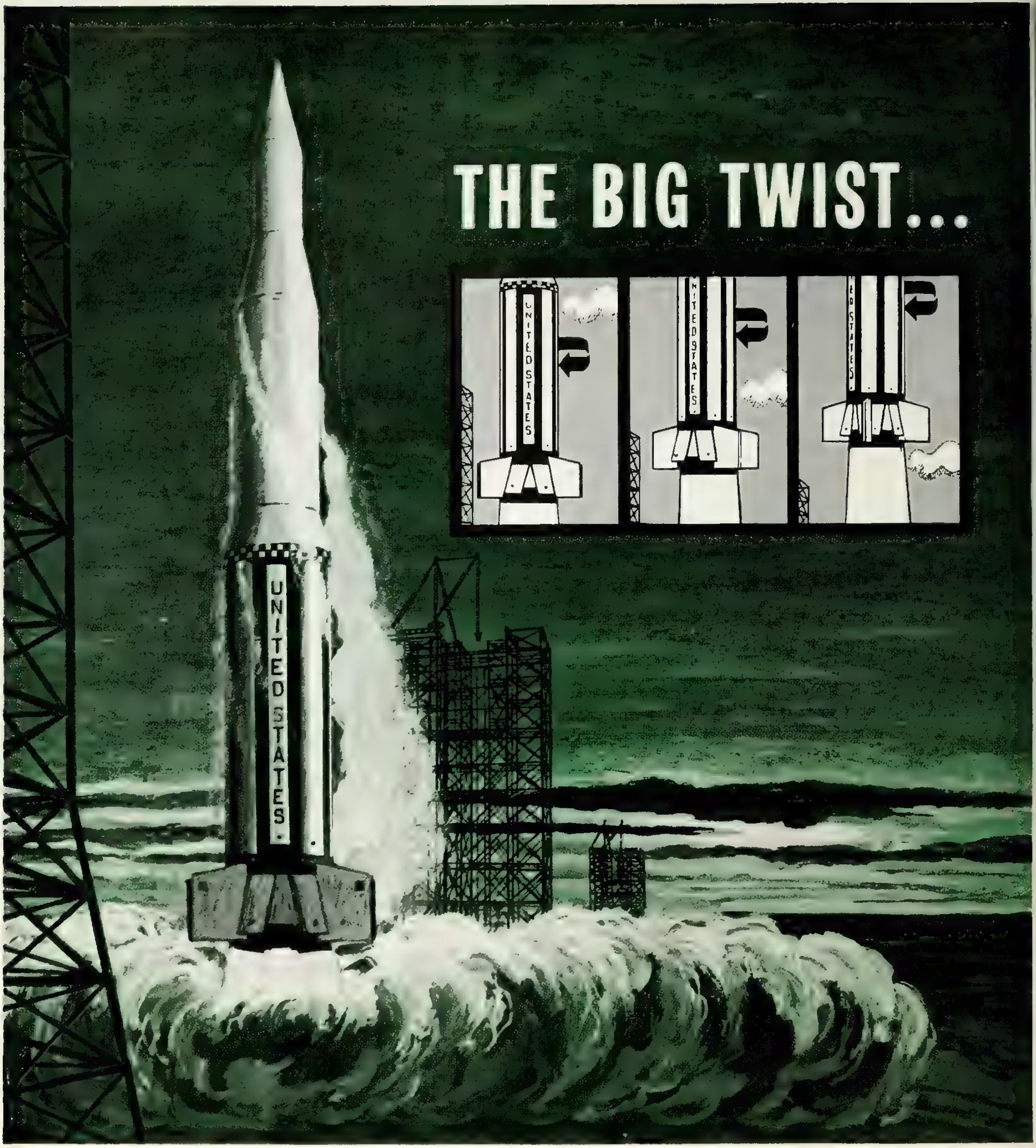

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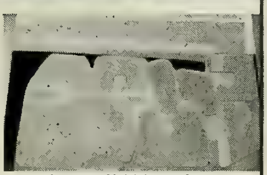
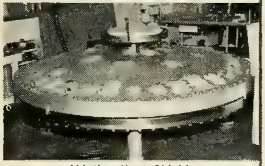


and Chem Blank ....Irregular Molybdenum Parts

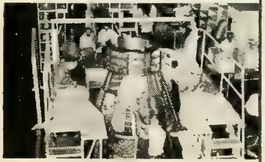
Hot Rivet ....Molybdenum Panels

Slurry Coat ....Columbium Panels

*Fusion Weld ....Thin Sheet Titanium

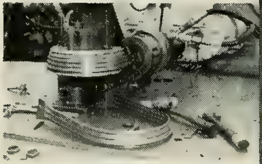


*Mold ....Ablative Heat Shields

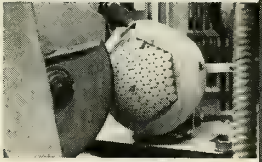


Assemble ....Man-Rated Spacecraft

Bend ....Molybdenum Corregations

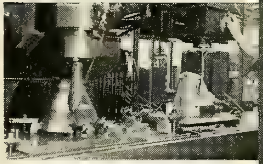


Stretch Form ....Columbium Structural Members

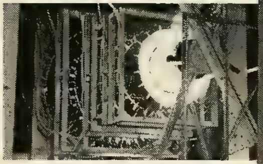


Grind ....Zirconia Nose Caps

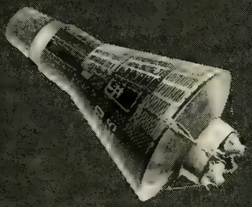
*Induction Braze ....Stainless Steel Tubing On Assembly



Mill ....Die Forged Molybdenum Nose Skirts



Test ....Full Scale Reentry Spacecraft



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Volume 14, Number 6 February 10, 1964

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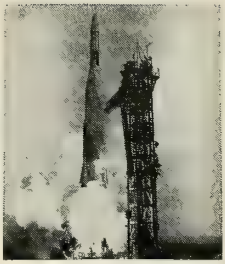

Jan. 30 liftoff from Cape Kennedy of Ranger VI atop Atlas-Agena booster. Launch phase and mid-course trajectory correction went smoothly, but the six TV cameras aboard the spacecraft failed to operate. They were to have sent back some 3,000 photos of the Moon. See story page 16.

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Instant radar

This helicopter is air-lifting a new, compact 3-D radar which can be taken to trouble spots anywhere in the world at a moment's notice. It meets the need for systems which can snuff out threats to peace wherever they happen.

Packaged in two small shelter-boxes, this ruggedly-built radar can operate in the most remote areas. Setup and on the air "instantly" (in about 30 minutes), it will monitor hundreds of aircraft in its area without any human attendant.

Unlike conventional radar, the "picture" of air activity it presents is three-dimensional—simultaneously and accurately showing distance, direction and height of aircraft. Thus, it is equal to the difficult task of locating and tracking today's supersonic targets. And, it can provide the information necessary for commanders to take swift, decisive action.

This compact 3-D radar is the latest application of Hughes' invention of *frequency-scanning* (i.e., electronic positioning of radar beams). Conventional radars move in a "rocking" fashion—mechanically positioning its beams to determine the altitude of targets. Hughes 3-D radar,

Now in operation, this new compact, lightweight radar antenna is part of the Hughes air-transportable 3-D radar system. Hughes has tested and demonstrated this system before representatives of U. S. and tactical teams of our allies.

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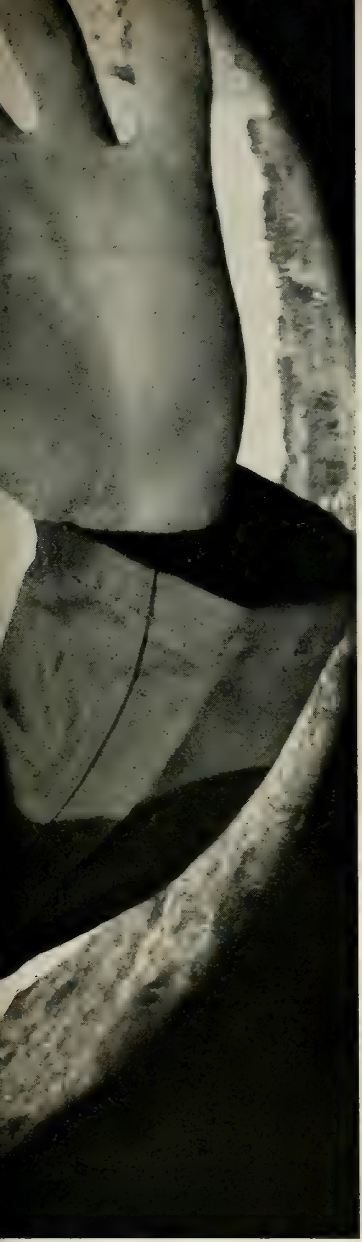

through electronic beam positioning, eliminates this movement. In the process it saves weight, allows a more compact easily-transported system, reduces cost.

Hughes in Fullerton delivered the first 3-D radar in 1957. Today, scores of these Hughes radars are deployed throughout the free world.

Engineers and scientists with abilities and interests related to this activity or to other Hughes programs in electronics and space are invited to inquire. Hughes is an equal opportunity employer. Please address: Mr. S. L. Gillespie, Manager, Employment and Manpower, Hughes Aircraft Company, Fullerton 59 , California.

letters

Ranger and JPL

To the Editor:

I am quite concerned by certain statements and their suggested implications in an article by Heather M. David in the Dec. 23 M/R (NASA Struggling to Hold to 1970 Man-on-Moon Schedule," p. 15).

The two statements appear at the bottom of the first column and the top of the second column. I quote: "Northrop had been brought into the *Ranger* program after NASA examined JPL's management and termed it inadequate for the reliability and production standards required in the spaceflight program. All five *Rangers* which have been launched were failures."

The first sentence refers to the so-called Kelley Report, which is a classified document, and since Heather M. David would not be able to establish a "need to know" basis, the contents of the report would not be available to her. She undoubtedly obtained her information through the published NASA hearings before the Subcommittee on Space Science and Advanced Research and Technology of the Committee on Science and Astronautics of the House of Representatives of the 88th Congress. In these published hearings, Subcommittee Chairman Joseph E. Karth (D-Minn.), who apparently did have access to the Kelley Report, in No. 3, Part 3A gives certain information concerning NASA, JPL, and the *Ranger* Program. This hearing report would probably be the most official and authoritative source of information regarding the subject under discussion.

May I commend the reading of these hearings to you. In them you will find absolutely no basis for a general statement such as the first of the two statements I have quoted from your periodical.

The second quoted statement is literally true, but when it is taken in the context of following the first statement, the implication will certainly be made that JPL was responsible for all five of the *Ranger* failures. This is certainly not true, since JPL cannot be blamed for the failure of a part of a system over which it has no control, such as the launch vehicle. I should expect one of the goals of a periodical such as MISSILES AND ROCKETS, as one of the leading periodicals in this field, would be to correct such general public misconceptions, which unfortunately are rather widespread and believed. Specifically, it is the duty of the editor to see that such implications as this do not, possibly, inadvertently creep into articles published in his periodical. As one who has had some association with the typographical world, accurate reporting is one of the first tenets of the trade, and one which, if not firmly established by the editor and nurtured and watered, will eventually kill any publication, other than a scandal sheet, faster than anything of which I know.

If after reading the Congressional hearings referred to above, the editor of a publication such as yours actually chooses to believe other than what the published statements therein indicated, he should make this belief known through the medium of an editorial, and not allow it to appear in a supposedly factual reporting type of article, such as the one under discussion.

Robert C. Wyckoff
Tujunga, Calif.

M/R cannot agree that the systems manager for a spacecraft program should not be blamed for failure of a part of that spacecraft's system. (See Editorial, p. 50.) —Ed.

Warmed by SA-5

To the Editor:

Re the Jan. 29 triumph of NASA and *Saturn SA-5:* At long last, something in which we can all exult without qualification!

Kudos to Marshall, Chrysler, Douglas, Rocketdyne, Pratt & Whitney, et al!

Rolf McTigue
Little Rock, Ark.

'Profile Of An Industry' Reprints

IN RESPONSE to widespread reader interest, MISSILES AND ROCKETS *has prepared reprints of the three-part "Profile of an Industry" series by Senior Editor William Beller. Based on recent surveys by U.S. Government agencies and the Stanford Research Institute (under a contract from the Aerospace Industries Association), the articles first appeared in the Oct. 28, Dec. 2 and Dec. 16, 1963, issues of M/R. Together they provide an unprecedented report on the growth of the Missile/Space industry—now the second largest employer in the United States —and its impact on the national economy and technology.*

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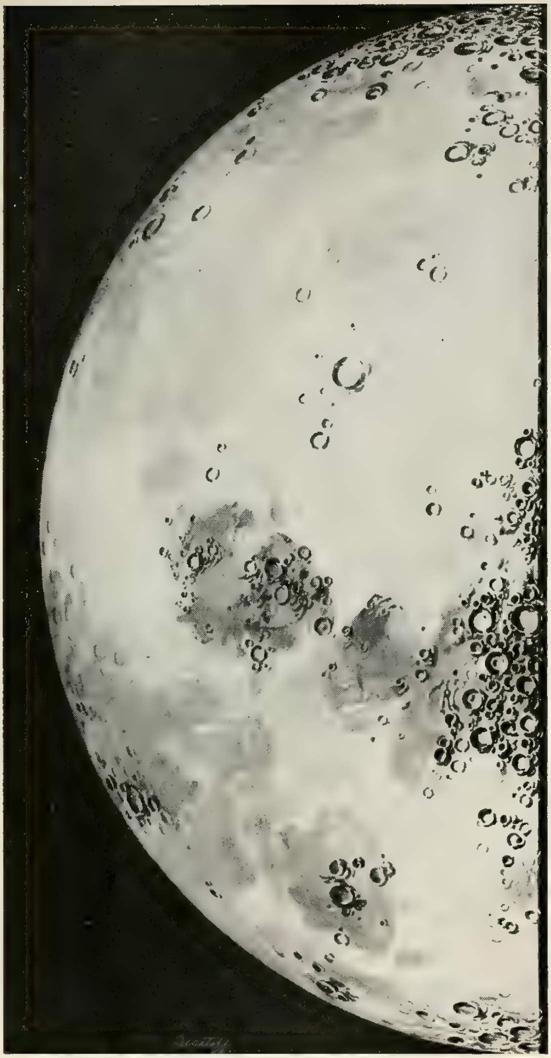
TRW SPACE TECHNOLOGY LABORATORIES In Perspective



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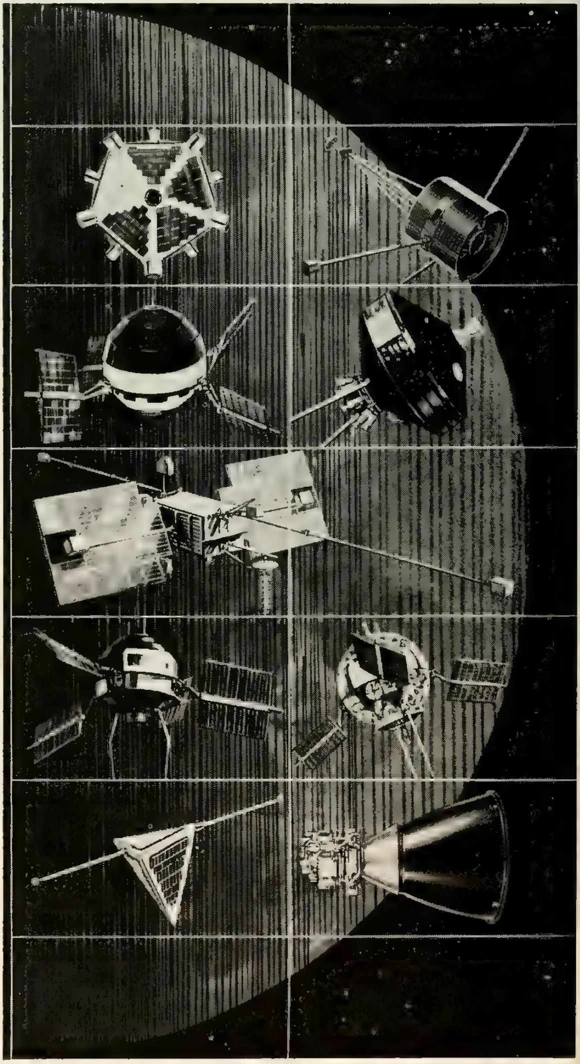

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The Countdown

WASHINGTON

NASA Breaks Down Supplemental Request

NASA's Fiscal 1964 supplemental budget request includes $19 million for *Apollo's* command and service modules and $12 million for Lunar Excursion Modules. The $110 million request for *Saturn V* includes $31.1 million for the first stage, $30.5 million for the second stage, $20.4 million for the third stage, $11.2 million for F-1 engine procurement and $16.8 million to buy J-2 engines.

Month-Long Flights Planned for MOL

One of the objectives of the Air Force *Manned Orbiting Laboratory (MOL)* program is to provide a shirtsleeve atmosphere for two astronauts for flights up to 30 days in duration. This compares with two-week maximum flights planned for NASA's *Gemini* program.

No Decision Yet on Apollo Backups

Manned space flight officials still have not decided what backup systems, if any, will be needed for Project *Apollo*. Lower-echelon officials have proposed quite a few such systems. Decision is not expected for several weeks.

Failure To Delay Ranger VII Launch

Delay of one to two months in the launch of *Ranger VII* is expected while NASA attempts to fix cause of the *Ranger VI* failure (see p. 16). *Atlas* booster for the *Ranger VII* mission was placed on the Complex 12 launch pad on Feb. 1. The *Agena* second stage currently is undergoing hangar checkout. Launch initially was set for the four-day window that opens Feb. 29 but this now is considered unlikely.

DOD Confirms Mauler Guidance Troubles

Dept. of Defense has confirmed that primary reason for the decision not to move *Mauler* out of development is failure of the guidance system to perform satisfactorily (COUNTDOWN, Jan. 6, p. 9). The system uses a target-illuminating radar initially and then switches to infrared-homing for terminal phase. Army presently is concentrating its efforts on the initial version of the air-defense missile. Plans for more advanced *Maulers* have been postponed.

NASA Plans for Big Solids Outlined

The space agency schedule for the large solid motor program in the next fiscal year calls for design, fabrication and test of two 260-in.-dia. motors each weighing 1.8 million lbs. and generating 3 million lbs. thrust. NASA also will fund design, fabrication and static test of a 156-in. motor to prove out a 3-million-lb.-thrust nozzle eventually to be used in the 260-in. motor.

No New Launch Vehicles Needed Soon

With development of currently scheduled boosters, there will be no military need for a new launch vehicle until after 1970. That's the opinion expressed recently by Dr. Albert Hall, space chief for Defense Research and Engineering. Hall also foresees a decrease in the number of boosters required in the National Space Program.

NASA To Use Aircraft for Apollo Tracking

NASA has decided to modify an aircraft to provide tracking capability during injection of the *Apollo* spacecraft into Earth orbit. To be paid for partly out of Fiscal '65 funds, the aircraft will be part of the manned space flight network which will include nine stations with 30-ft. antennas, three 85-ft. antenna sites, one insertion ship, two ships for coverage of the early translunar period, and two re-entry ships.

Army Steps Up Pershing Requirement

Number of launchers in each *Pershing* missile battalion is to be increased. Presently, each unit is equipped with four launchers. During Fiscal '65, this number is to be increased —probably by two more launchers. This will significantly increase quick reaction capability of the *Pershing* system.

NASA Foresees Mars Exploration

U.S. planning for exploration of Mars will be definitized by 1969, according to associate NASA administrator Dr. Robert Seamans, Jr. This probably would push any actual landing attempt into the 1980's.

Titan III Growth To be Exploited by DOD

Dept. of Defense has allocated funds in the FY '65 budget for definition of design and performance parameters of a new high-energy upper stage for *Titan III*. Money also is provided for advanced liquid propulsion concepts. With the high-energy upper stage, payload capability of Air Force's *Titan III* to a 24-hr. orbit would jump from 2,200 lbs. to 8,000 lbs. With a new propellant, the payload would increase to 5,000 lbs.

Synchronous MetSat Program Slowed

With no FY '65 money for hardware development of a *Synchronous Meteorological Satellite*, the project will be restricted next year to experimental tests. Some flight experiments planned are for study of required operating modes of the optical system, of the wide range of light values to be observed, and of other optical problems involved. Effects of sensor motion on spacecraft stabilization and station-keeping also will be studied.

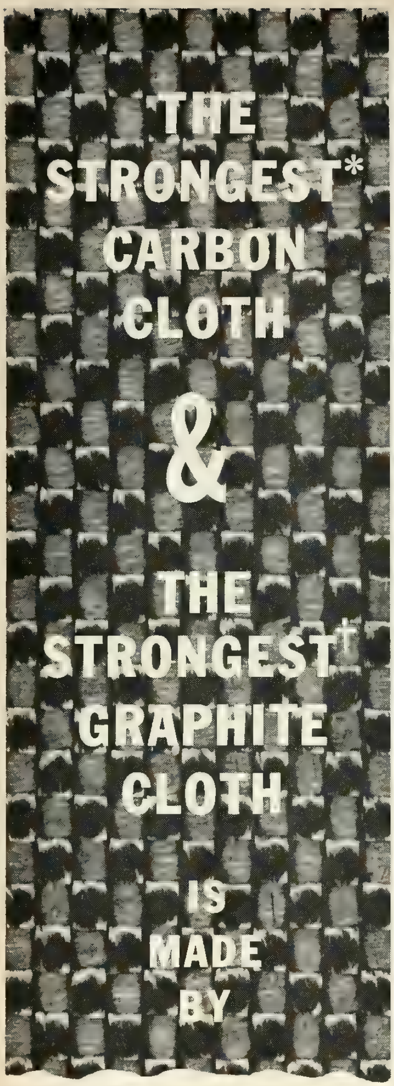
INDUSTRY

MOL Requests Due by 'Latter Half'

Industry will receive Requests for Proposals on the Air Force *Manned Orbiting Laboratory* by the "latter half of this year," according to Dr. Albert Hall, Dept. of Defense space deputy. He said in Los Angeles last week that initially only a relatively small number of flights are envisaged for *MOL*—about six, although this could be expanded.

Astronauts Could Control Boosters

In 130 simulated flights by future astronauts, Martin Marietta found that a pilot could stabilize a large three-stage booster and inject it into a desired orbit. Ejection into a specified window, with aid of a simple guidance computer, was achieved in 50% of the flights. Martin concluded that an astronaut potentially represents a highly effective short-term backup for a flight control system.



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The Missile/Space Week

Blue Steel Gets New Lease

Britain has announced success in efforts to modify the *Blue Steel* air-to-surface missile and its carriers, the Vulcan and Victor bombers, to fill the deterrent gap left in that country by the U.S. cancellation of *Skybolt*.

Modifications to the bombers will increase their range at altitudes low enough to permit radar penetration. The *Blue Steel* has also been altered for low-level operation.

Britain's Secretary of State for Air Hugh Fraser predicts that the accomplishments will extend the useful life of Britain's force of 200 V-bombers until around 1970, when that country's main nuclear deterrent is expected to be *Polaris*-firing submarines.

Blue Steel is capable of speeds up to 3,000 mph and carries a nuclear warhead of the 1-megaton class. Its range is secret, but speculation is that it may have been extended to 500 mi.

Military Space Budget Discussed

Expenditures for military space in the next several years are not expected to rise substantially over the $1.5-billion average of the past three years, Dr. Albert Hall, deputy director for space, Directorate of Defense Research and Engineering, told a convention of the Institute of Electrical and Electronic Engineers in Los Angeles.

Operational deployment of spacecraft will be withheld until their performance has been assured, Hall predicted. This will lead to increased emphasis on ground testing or aircraft flight tests of components before a spacecraft is launched.

The goals of DOD space efforts, according to Hall, should be:

—Satellite lifetimes of more than a year of payloads with more than 10,000 active components

—Proving techniques for stabilizing satellites at low, medium and synchronous altitudes

—Achieving space electric power supplies of long life, at 1-15 kw.

—Launch and vehicle reliabilities with a launch success ratio of 0.85

—New progress toward recoverable boosters

—Development of maneuverable upper stages

—Major improvements in sensors.

Among the areas in which the U.S. is already well advanced Hall listed communications, weather observation and navigation. The needs in the areas of ballistic missile defense and ASW are also important.

"Defense experience has been solely with unmanned vehicles," Hall pointed out. "Today's status report clearly shows that the largest unknown in military space is still man himself."

Therefore, the *MOL* program has been established as a means of answering questions about man's mission and value as part of a manned military space system. The objectives of *MOL* are: providing a minimum in-space test facility at an early date; providing a measure of man's usefulness, preceded by aircraft and ground simulation tests; equipping the *MOL* capsule with components already under development or within the state of the art; dividing a reasonable, attainable schedule for development and cost; and providing a basis for orderly future growth if initial experiments show *MOL's* feasibility.

Shots of the Week

Russia followed NASA's *Ranger VI* shot of Jan. 30 (see p. 16) with a Jan. 31 launch of two *Elektron* scientific satellites aboard a single rocket to conduct research on internal and external radiation belts of the Earth and physical phenomena connected with them. *Elektron-1*, the first of the satellites, was separated from the booster before expiration of the first stage. The launch vehicle then regained the necessary velocity to place the second satellite into orbit.

- The Navy on Feb. 3 successfully launched a *Polaris A2* ICBM from the submarine James Monroe, submerged off the Florida coast near Cape Kennedy.
- NASA used Nike-Cajun rockets in a Feb. 3 investigation of a puzzling mass of warm air moving from Europe. Shots were from Wallops Island, Va., and Ascension Island in the South Pacific.

Standards Exchange Revealed

The National Bureau of Standards and a team of Soviet measurement experts announced a preliminary three-point agreement for extended cooperation in the area of measurement and standards data exchange.

The disclosure came at a press conference in Washington, Feb. 1, concluding a month-long visit by five Russian metrologists to measurement laboratories in the U.S.

The points agreed upon include: 1) exchange of data on observations of standard time and frequency signals from various radio stations, observed in terms of atomic frequency standards; 2) exchange of calibration information to compare measurements of various electrical and electronic quantities, and 3) the regular exchange of publications of the National Bureau of Standards and the USSR Committee on Standards, Measures and Measuring Instruments.

The scientists recommended the exchanges be coordinated through the International Bureau of Weights and Measures, located in Sevres, France.

NASA Updates SA-5 Information

The Marshall Space Flight Center estimates that the material put into orbit by *Saturn SA-5* will remain about 500 days. The longer orbital time (estimates had been one year) is attributed to a greater than expected insertion velocity.

Apogee is 470 mi. (70 more than expected), and perigee is 167 mi. (7 more than expected). Other data received by Marshall indicated that other aspects of the flight went almost exactly as planned.

GE To Simulate Nuclear Effects

General Electric's Space Sciences Laboratory at Valley Forge, Pa., under contract to the Army's Ballistic Research Laboratory, is developing a technique to simulate in the laboratory the shock effects that an exploding nuclear anti-missile weapon would have on an incoming missile.

The project is a substitute for actual high-altitude explosions (outlawed by the nuclear test treaty) as a means for testing vulnerability of ICBM's to the pressure waves generated by nuclear bursts.

Heart of the effort is a nuclear effects simulator, called the Magnetic Shock Generator.

Solar Flare Ideas Challenged

The likelihood of a space traveler encountering a solar superflare is apparently no greater during a period of maximum solar activity than during a minimum period, according to two American solar experts.

This conclusion, by Herbert Friedman of the Naval Research Laboratory and Martin A. Pomerantz of the Franklin Institute, may help quell

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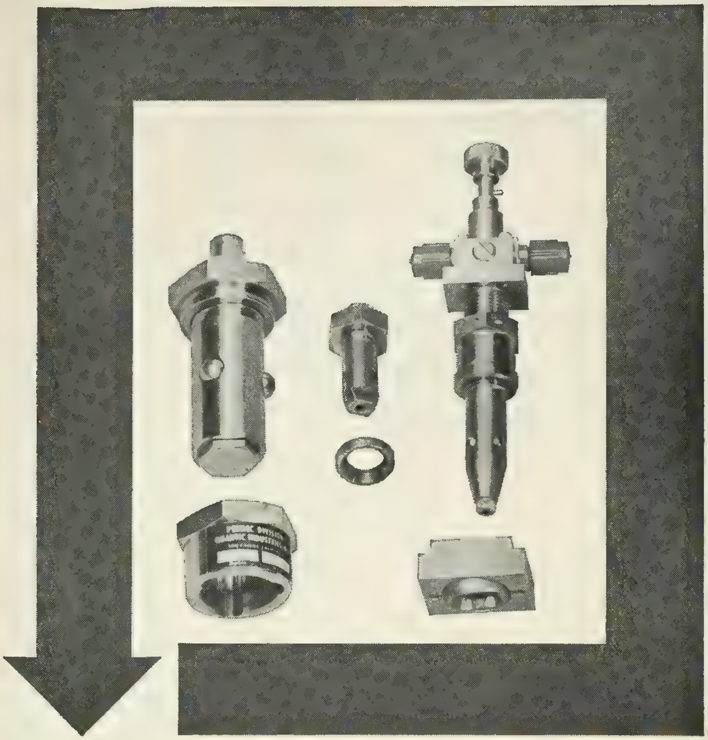

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fears expressed in the U.S. and Russia in recent months that Moon-bound astronauts would be less susceptable to the dangers of superflares in 1975, during a period of minimum solar activity, than in 1970 when activity will be maximum.

Friedman and Pomerantz discussed their solar flare findings last week at the National Academy of Sciences during a news conference. The conference was called to announce that the Navy launched a satellite Jan. 11 to monitor solar X-rays in conjunction with scientific studies during the International Years of the Quiet Sun (Jan. 1, 1964-July 1, 1965).

Boeing VP Resigns

Boeing senior vice president Wellwood E. Beall has resigned to "take it easy" for "six months or a year." A company announcement indicated that Beall, who is also a director of the Seattle firm, will be on leave of absence.

Beall, 56, joined Boeing in 1930, and became senior vice president in 1952. He said he resigned to take care of "personal business."

Boston Remains Favorite

NASA Administrator James E. Webb has reaffirmed the space agency's original choice of Boston as home for its new electronic research center in a letter to House Speaker John W. McCormack.

Webb told McCormack that, after extensive re-examination of the first recommendation, NASA still feels that Boston is the best site for the $50-million center.

If the recommendation of NASA is not vetoed by Congress within 45 days, planning to locate the center in Boston will be permitted to proceed.

MOL Chief Named

Col. R. K. Jacobson has been named to the new post of Assistant Deputy Commander for Space for *MOL* in the Air Force Systems Command. AFSC Commander Gen. Bernard A. Schriever said the new office will be the center for all AFSC actions related to the *MOL* program and that Jacobson, in addition, will be responsible for staff management and review in the program.

At AFSC headquarters level, therefore, he will be responsible for any action tailoring *Titan III* as a booster for *Gemini-X/MOL*, which he will also manage separately as portions of the overall manned space station effort.

Circle No. 4 on Subscriber Service Card

Digital Guidance Computers: USAF TITAN II and TITAN III; NASA SATURN I, SATURN IB, SATURN V; GEMINI spacecraft. **Space Simulation Laboratory:** closed-loop simulation with space capsule, offering operational realism. **Space Systems Integration:** GEMINI spacecraft guidance system involving inertial guidance and digital computation. **Tiros Weather Satellite:** satellite position and attitude determination; photo data processing. **Space Communication Techniques:** displays, tactical data processors, data compaction, language processing. **Ballistic Missile Defense:** surveillance and tracking, decoy discrimination, weapon control. **Phased Array Radar:** digital control of search and tracking. **Real-Time Computational Control:** GEMINI and APOLLO manned space flight. **Terrain Avoidance Radar.**

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Re-study ordered . . .

DOD Stalls Navy Tactical Probe

Announcement of program-definition phase contracts had been expected this month for Sea Star-type data-gathering system

DEFENSE DEPARTMENT officials have thwarted the Navy's plans to award two program-definition contracts for a tactical probe for fleet operations. Although the announcement of the awards had been expected this month, the Navy has now been told to "re-study" its requirements and come up with "the best and least expensive method" to develop a probe of this kind.

Formerly known as *"Sea Star,"* the probe would consist of multiple, interchangeable payloads for communications, meteorological and electronic warfare data gathering. The booster for the probe reportedly would be a *Terrier* or *Talos* with a high-impulse second stage. The probe could be launched with existing shipboard equipment.

The request for proposals for *Sea Star* (M/R, Oct. 28, p. 16; Aug. 5, p. 15) called for development of the payloads and integration of these payloads with both the booster and the shipboard terminals.

Bendix Corp. and the Astronautics Div. of Ling-Temco-Vought were thought to be front-runners for the $250,000 program-definition contracts. One of the two eventually is expected to be selected for the tactical probe program projected to eventually cost some $40 million.

The unsuccessful bidders were Raytheon Co. and two teams: RCA and Beech, plus Hughes and Sylvania. Twelve companies had originally been solicited.

- **Long time need**—For the past three years, the Navy has been pressing for a sea-based tactical reconnaissance capability. Originally, Navy officials proposed off-the-shelf satellite payloads that could be launched by *Sea Scout* and would provide a task force commander with an up-to-date appraisal of the tactical situation.

Sea Star was a more limited approach to the same problem. The payload would be launched to ranges of 50-300 miles from the force and then would descend by parachute. During descent, it could radio back to the task force data on the electromagnetic environment of the area, the prevailing weather conditions, the level of nuclear radiation and perhaps detect the presence of enemy surface or underwater ships. The payload could also be used for over-the-horizon communications during periods of nuclear blackout.

It is expected that *Sea Star* could provide at least 15 minutes of usable data.

- **Future uncertain**—The reasons for the DOD reversal of its approval for the six-month program definition are not clear. It is thought, however, that this is only a temporary setback and that the program eventually will be approved.

In addition to cost, the most likely reason for the re-study order appears to be the present Navy examination of an improved *Terrier-Tartar-Talos* versus a new advanced missile system. If Navy studies show that the development time of the new missile is significantly long, improved versions of the "Three T" family will be procured. If the new missile can be developed at an early date, it will be incorporated into the fleet in place of the Three T family.

Sea Star, since it will use the basic fleet air defense weapon as its booster, most likely will have to wait until DOD has assured itself that the system would be compatible with whichever approach is taken for fleet air defense. ■

LBJ Cites Redeye, Shillelagh, Walleye Progress

PRESIDENT Lyndon B. Johnson singled out three "highly advanced" tactical weapons systems for special praise at his news conference last week. The three—*Redeye, Shillelagh* and *Walleye*—are now completing development, the President said.

With *Redeye,* the President noted, "for the first time our ground combat soldiers will be able to fight back against a high-performance enemy aircraft." Shoulder-fired, the heat-seeking missile has a "very high probability of scoring" a hit.

Originally proposed for procurement in FY '61 and every subsequent year, *Redeye* suffered development difficulties particularly with its infrared homing device. The Army, however, is confident the development problems have been licked and proposes initial procurement in FY '64 with $19.0 million more programmed in FY '65. Pomona Div. of General Dynamics developed *Redeye.*

Shillelagh—an antitank missile to be mounted on the General Sheridan armored reconnaissance airborne assault vehicle—"has successfully completed engineering tests and is being released for production," President Johnson said. "So accurate that it can destroy a tank at a range of several thousand yards," *Shillelagh* is the first guided missile to be fired from a gun tube from which conventional ammunition can also be fired. The *Shillelagh* system was developed for the Army by the Aeroneutronic Div. of Philco Corp. Procurement in FY '65 will amount to $36.0 million.

Walleye, the third system mentioned by the President, is a TV-guided glide bomb developed by the Naval Ordnance Test Station at China Lake, Calif. "It has shown amazing accuracy at a range of several miles," the President noted.

First launch in mid-'65 . . .

Interim Weather Satellite Plan Ready

THE SPACE AGENCY is expected to forward to the U.S. Weather Bureau in the near future a developmental plan for an interim weather satellite system which will feature two orbiting "wheeled" *Tiros* satellites.

Development of the new system was signalled by the recent NASA-Commerce Dept. agreement spelling out the roles of the space agency and the Bureau in the operation of the National Operational Meteorological Satellite System (NOMSS).

The first 300-lb. *Intermediate Meteorological Satellite* is expected to be launched by mid-1965. It is hoped the system will become operational in the same year.

Under the new agreement NASA is to develop the spacecraft to specifications and requirements established by the Weather Bureau, which will operate the system as part of the National Meteorological Service.

The Bureau will determine the schedule of launches as well as the information to be gathered by the satellite instruments. Once NASA has placed the satellites in orbit the Bureau will operate and control the system and will analyze, process and distribute the data.

The space agency will also design, procure, test, launch and track the satellites.

The Weather Bureau said it presented specifications for the system to NASA some time ago. The first step in the system, preparation of the development plan was to go from NASA to the Bureau late last week or early this week. It will detail how the space agency expects to develop and procure the satellites.

• **Further ahead**—Meanwhile, Dr. S. Fred Singer, head of the Bureau's Satellite Operations, continues to maintain that ultimately the system will require a 4,000-lb. satellite in a 1,500-mi.-high polar orbit with readout to a single ground station.

This satellite would probably be integrated with the Satellite Collection of Meteorological Observations (SCOMO) program. At present, the Weather Bureau pays about $500,000 annually to get weather data from ships to Washington. Incremental cost of adding a SCOMO package to the meteorological satellite would be $50,000 a year, said Singer. The figure becomes even more favorable if other sources such as unmanned buoys are also tied into the System.

Going to an *Intermediate Meteorological Satellite* based on *Tiros* technology instead of *Nimbus* should save $125 million, Singer claimed. A test satellite, of the *Tiros* type but with its spin axis perpendicular to the plane of orbit, will be launched soon. The 300-lb. *IMS* will follow within a year.

Weaknesses in the 750-lb. *Nimbus* satellite criticized by Singer were the constant motion required for the solar panels and the complexity of the attitude control system. *Nimbus* continues as a NASA research satellite. ■

LEM Design Changes Keep Weight Within Goals

DESIGN CHANGES made on the Lunar Excursion Module (LEM), mostly growing out of the first NASA/Grumman Aircraft Engineering Corp. review of the LEM M-1 mockup last September, have enabled spacecraft planners to remain within the original weight goals despite other weight-adding modifications made necessary earlier in the program, according to LEM project sources.

The major areas of weight reduction resulted from the decision to use only two main propulsion tanks for the ascent stage rather than the original four, and from the substitution of a strap-like astronaut restraint scheme that eliminates the two cockpit seats.

Engineers are also continuing to make progress in transferring equipment, primarily scientific gear, from the ascent stage to the descent stage, thereby easing the fuel penalty paid by the ascent stage.

Since the ascent stage must have fuel enough to abort with its own weight during the descent, the aim is to put everything that is not absolutely needed for ascent into the descent stage. Though some success has been achieved, engineers say they would like to be able to transfer a lot more equipment.

They also add that even if some lunar exploration equipment is carried down in the descent stage, capability must be allowed in the ascent stage to bring at least some of it back.

The LEM weight, under its current trajectory plans and configuration, including the design changes, is still 25,500 lbs.

Design of the astronaut restraint system is not yet frozen. The major weight increases in LEM weight since work began have come in landing gear redesign. The system has evolved into a retractable four-legged configuration, with a gear radius of 180 in. and a 30-in. bearing pad on each leg.

Details of the gear redesign were first reported in a Missiles and Rockets special report on LEM July 15, 1963, p. 23. Use of the retractable four-leg scheme in comparison to earlier plans to use a fixed five-leg version yields a larger footprint for LEM and greater expected stability upon a still-undefined lunar surface.

The lunar surface model used in the LEM design has also shifted since the original proposal, which brought on most of the gear changes. Engineers on the project have learned through vehicle landing stability analysis that LEM is very sensitive to changes in gear geometry.

The system must be capable of handling the anticipated vertical and horizontal velocities, and still not have the vehicle flip over because of a marginal instability problem. The energy must be absorbed without forcing the vehicle into very high rotational velocities.

Failure of the *Ranger VI* to deliver lunar surface photos dealt a very frustrating blow not only to Jet Propulsion Laboratory scientists, but also to those now wrestling with the uncertainties of LEM gear design.

Failure of a mission . . .

JPL Looks for Answer To Ranger VI Malfunction

NASA names five-man board headed by Hilburn to review findings and determine the future course of the program

by Rex Pay

PASADENA, CALIF.—Jet Propulsion Laboratory reported there had been no indication late last week as to what caused the failure of the *Ranger VI* television system.

JPL was re-simulating the entire mission in an attempt to duplicate the failure.

At the same time, NASA has appointed a five-man board to review JPL's findings after the analysis of the camera failure is complete. Results will be used to determine the future course of action in the *Ranger* program. The board is headed by Earl D. Hilburn, NASA Deputy Associate Administrator for Industry Affairs.

- **Happy start**—The 65-hr., 35-min. *Ranger* flight to the lunar surface started routinely aboard *Atlas 199-D* at 10:49:03 a.m. EST Jan. 30 from Complex 12 at Cape Kennedy.

Both *Atlas* and the *Agena* second stage performed perfectly. Thirty minutes and 20 seconds after liftoff, the spacecraft was separated from the *Agena* by a set of springs. The solar panels deployed exactly one hour after liftoff.

The remainder of the flight was nominal, with a mid-course burn being used to slightly change the trajectory and assure that the spacecraft would land in the lunar area known as the Sea of Tranquility. The spacecraft attitude was so near optimum that no correction was required during the terminal descent to orient cameras toward the lunar surface.

Ranger VI impacted in the Sea at 4:24 a.m. EST Feb. 2, precisely on schedule. But the two independent camera systems failed to provide signals during the last 10 minutes of flight, when they were to have taken and transmitted nearly 3,000 pictures of the Moon at altitudes ranging from 900 to 4 miles.

- **Deterioration**—Telemetry received throughout the flight indicated that the batteries powering the two systems were fully charged and at the correct temperature.

Following the mid-course maneuver on Jan. 31, impact predictions showed that a clock preset at launch would switch on half of the TV system—the wide-angle cameras—to warm up at 19 minutes before impact instead of the 30 minutes planned.

Normally this timer would have been inhibited by radio command, and the warm-up would have been initiated by the central computer and sequencer (CC&S) 15 minutes before impact. But, because it was not needed for a terminal maneuver, the CC&S was not activated and the clock was not inhibited.

The extra four minutes of warm-up should not have been detrimental to the system, which is designed with the capability to operate for one hour at full power from its batteries.

The second set of cameras was switched to "warm-up" four minutes later by an RTC7 command sent from the ground. This backed up the timer and would have switched on the first set of cameras if the timer had failed.

This signal also initiated a timer in the camera sequencer system. The timer should have switched the TV system on to full power five minutes later, at impact minus 10 minutes.

When the signal did not appear, a second RTC7 command was sent. This should have turned off one television camera system and impressed 90 channels of emergency telemetry onto its transmitter carrier. The other carrier should have continued to bear TV pictures.

Nothing happened.

A third RTC7 command was sent. This should have restored the system to normal, with each transmitter sending back television signals at a power of 60 watts. Nothing happened.

Nothing else could be done. Sending a fourth RTC7 signal would have switched off the equipment completely.

Right up to impact, there was no sign of full-power video.

- **Telemetry**—During the end of the flight, the 2.5-w, 110-point telemetry system in the spacecraft continued to send signals via the high-gain antenna. Fifteen of these data points were temperature and voltage readings in the TV system.

According to JPL, the only indication these 15 data points gave of the state of the television system was a slight drop in battery voltage—one-sixteenth of a volt—which *may* have signified that the system went into the warm-up mode. Also, a pulse received from the partial-scan camera channel indicated that warm-up might be taking place.

There were 90 points of telemetry in the TV channels, which would have indicated how the system was performing—if they had functioned. This telemetry would have been transmitted on one of the camera channels.

- **Landing**—The mid-course maneuver was intended to deflect *Ranger* from an apparent 600-mi. miss to a course that would take it to a point at latitude 8.5° and longitude 21.0°. Orbit determination data up to one hour before impact led JPL to compute the probable area of actual impact as somewhere in a 20-mi. circle centered at latitude 9.39°, longitude 21.51°.

This area is in the Sea of Tranquility —considered by many a very suitable landing site—at the center of a triangle formed by the craters, Arago, Sosigenes and Ross.

The same data produced a JPL prediction for impact time of 9 hr., 24 min., 32.18 sec. GMT on Feb. 2. Telemetry signals received at Goldstone DSIF terminated at 9 hr., 24 min., 33.15 sec. —at both the *Pioneer* and the *Echo* sites. Subtracting the time for the signal to come from the Moon gives an error in impact prediction of 0.32 sec.

- **Review panel**—In addition to Hilburn, members of the review board appointed by NASA are Herman LaGow, Systems Review Group, Office of Space Science and Satellite Applications, Goddard Space Flight Center; Francis Smith, Chief of the Instrument Research Div., Langley Research Center; Walter Jokobowski, *Ranger* program engineer, Lunar and Planetary Programs Div., OSSA; and Eugene Dangle, Secretary, Technical Program Officer, Office of Program Review, NASA Headquarters. ■

In House budget testimony . . .

Air Force Proposes Improved Defense Against Sub-launched Missiles

Industry observers feel LeMay disclosure, already submitted to DOD, envisions a long-endurance missile-firing platform

by James Trainor

THE DEFENSE DEPARTMENT is studying an Air Force proposal to increase both the reliability and amount of warning time against submarine-launched ballistic missiles.

Gen. Curtis E. LeMay, Air Force Chief of Staff, disclosed in testimony before a Congressional committee that the plan had been submitted to DOD.

"Obtaining warning against submarine-launched ballistic missiles (SLBM's)," LeMay told the House Armed Services Committee last week, "will be difficult to achieve due to the relatively short time of missile flight. The system designed for this purpose must provide both the required degree of reliability and the maximum amount of warning."

The Air Force proposal would meet both these requirements, LeMay asserted. Details of the plan were not revealed, although LeMay's statement was widely interpreted to include a defense against the sub-launched missile.

- **Three out of three**—In testimony before the same committee, Secretary of Defense Robert S. McNamara had outlined three distinct capabilities required for a defense against submarine-launched missiles:

—Detection and tracking of enemy submarines;

—Destruction of these submarines before they have an opportunity to launch their missiles;

—Detection, tracking and destruction of the missiles once they have been launched.

Nike-X, the Secretary said, would constitute the third capability and would provide the "primary" defense against submarine-launched missiles. As an interim step, DOD has been modifying air defense radars to give them some capability against shorter range SLBM's. Tests of these radars have been successful, and $15.9 million is included in the FY '65 program to convert selected air defense radars.

To provide the second capability, the Secretary is relying on the Navy's ASW forces. The first capability is to be provided by continued research on ASW detection devices under projects Artemis and Trident—including continued development of aircraft-monitored sonobuoys.

- **Flying interceptor platform**—LeMay's proposal, in the opinion of some industry observers, might be a move to combine all three capabilities into one weapons system—a long-endurance missile firing platform. The idea, they say, would be to detect and keep under constant surveillance hostile submarines within missile range of the U.S. from an aircraft that could stay aloft for a number of days.

If the submarine fired a missile, the missile platform could intercept it in the boost phase and then attack the submarine that fired the missile. Such a proposal, industry observers note, would combine the *BAMBI* concept for boost intercept of ballistic missiles with proposals for a long-endurance missile platform for strategic missions.

BAMBI—an acronym for "Ballistic Missile Boost Intercept"—is an Air Force concept for a system of approximately 1,200 satellites armed with heat-seeking interceptors. These satellites, because of their number and orbital positioning, would provide continuous coverage of the Soviet Union so that they would always be in position to destroy any missile during its vulnerable boost phase.

ARMY MISSILE PROCUREMENT FY '65

SURFACE TO AIR	FY '65 Program* ($ Millions)
Hawk**	10.0
Nike-Hercules**	1.8
Redeye	19.0
SURFACE TO SURFACE	
Honest John	6.3
Lance	4.3
Little John**	0.8
Pershing	46.8
Sergeant**	7.3
Shillelagh	36.0
SS-11	17.2
OTHER SYSTEMS	
Multisystem test equipment	29.7
Target Missiles	10.4
OTHER COSTS	
Modifications, and industrial facilities	59.4
First destination transportation	9.6
Selected repair parts	24.0
TOTAL	282.6

* Includes cost of associated ground equipment.
** Bought out in FY '64.

Several contractors made detailed studies of the concept in 1960. However, both the cost and the unattainable reliability required precluded development of the system.

The long-endurance aircraft concept has been mentioned favorably by McNamara as a possible successor to the manned bomber, while the LeMay proposal, if industry observers are correct, would satisfy McNamara's requirements for multi-capabilities in weapons systems.

"Although *Dyna Soar* has been terminated," LeMay emphasized, "a need still exists for development of a maneuverable aerospace craft capable of controlled re-entry and precision recovery, ferrying missions to and from a space laboratory, transfer of men and equipment in space and a wide range of other roles."

- **Army missile procurement**—In other testimony before the committee, Lt. Gen. Robert W. Colglazier, Jr., Army Deputy Chief of Staff for Logistics, said procurement would be dropping off sharply from $447.5 million in FY '64 to $282.6 million in FY '65. Army missile procurement is mainly for four systems—*Pershing, Shillelagh, SS-11* and *Redeye*. The other major missile procurement is the multisystem test equipment for *Shillelagh* and *Lance* as well as for *TOW*, *Mauler* and *AADS-70* when these systems come into the inventory. (See table).

Initial procurement money for *Lance* in the '65 budget will be limited to the missiles and ground equipment required for maintenance engineering and training. The *Shillelagh* procurement, although a substantial amount, represents a minimum commitment to the program. ■

Budget document shows . . .

NASA Eyes Apollo Follow-on Systems

by Hal Taylor

NASA IN FISCAL '65 will begin preliminary engineering development for the first follow-on to the manned lunar landing program, the *Apollo Logistic Support System (ALSS).*

The space agency is also studying two more advanced programs, the *Stay Time Extension Module (STEM)* and the *Lunar Exploration System for Apollo (LESA).*

Existence of the new programs—which have not yet received Congressional approval—was revealed in a budget document presented to the House Space Committee.

The report disclosed that funding of the *Apollo* Command and Service Modules will rise from $508 million to $520.4 million. Most of the money will go to North American Aviation, Inc.'s Space and Information Systems Div., and to the firm's subcontractors. Funding of the Lunar Excursion Module will also rise from $144.5 million to about $190 million.

In the space science area, the agency told Congress that its heavy *Observatory* spacecraft series will cost well over half a billion dollars. At the same time, NASA expects to launch seven to ten small *Explorer*-type satellites per year through the end of the decade.

- **No room for cuts**—Details of the budget document were learned as NASA Administrator James E. Webb warned the committee that the lunar landing program will slip into the 1970's unless NASA's FY '65 budget request of $5.304 billion is approved.

Webb told the committee that he hopes Congress "will give us a fighting chance of meeting the goal of landing a U.S. astronaut on the Moon by the end of this decade."

"At the budget levels requested by President Johnson, we will have it and the cost will be substantially less than if there are stretchouts."

He said NASA can still promise to achieve the lunar landing at less than $20 billion, but "if the program is further curtailed, if the momentum is lost, if the *Apollo* program is stretched into the next decade the cost will not be under $20 billion, it will be several billions more."

Webb said that a NASA study found that "the cost of lunar exploration would increase by approximately $1 billion for each year that the landing is delayed (M/R, Nov. 25, p. 37). A three-year lag would cost $3 billion with no corresponding improvement in the benefits obtained."

Later, Deputy Administrator Dr. Hugh L. Dryden told the committee that Congress must soon give thought to follow-on activities after *Apollo.*

He noted that postponing schedules and decisions on future programs is part of the history of Federal participation in R&D, which has been one of "repeated preoccupation with the current requirements of the nation at the expense of, or to the neglect of the basic, long-range efforts needed by any nation which hopes to maintain leadership in the vital areas of science and technology."

(MISSILES AND ROCKETS this week presents a detailed breakdown of the Manned Spaceflight and Space Science and Application R&D portions of the presentation [see opposite page]. In subsequent weeks, it will publish breakdowns on the R&D budget for the Offices of Advanced Research and Technology, Tracking and Data Acquisition, as well as the construction budget for the agency.)

- **Future outlines**—NASA said *ALSS* is the most probable system for support of early lunar exploration missions. It would consist of an unmanned *Apollo* Lunar Excursion Module (LEM) descent stage, modified to be capable of landing 7,000 lbs. of supplies on the lunar surface.

ALSS, similar to the lunar logistics system studied previously by the space agency, would carry such equipment as surface vehicles and shelters to extend the mobility, stay time and capability of *Apollo* astronauts.

"Following program definition studies during FY '64," the agency told Congress, "it is anticipated that preliminary engineering work will be initiated in Fiscal 1965."

This will include essential supporting development, detail design, preliminary mock-ups and test articles.

Another advanced project being considered by the space agency, *STEM,* would also make use of the LEM modules. It would be modified to provide what NASA calls "a modest extension of lunar surface stay time for the astronauts beyond that presently provided."

The principal system being investigated for subsequent, more extensive operations is the *Lunar Exploration System for Apollo (LESA).* It would be a flexible system capable of providing a lunar base. It is conceived as a modular set of lunar surface hardware which can be quickly tailored to support a wide range of lunar exploration missions. The system includes surface vehicles, shelters, nuclear power plant, appropriate support equipment and regenerative systems to reduce resupply requirements. *LESA* would be designed to support up to 18 astronauts for long-duration missions.

- **Apollo progress**—The NASA presentation also reported that the FY '65 budget request for the *Apollo* spacecraft will complete most of the testing of development spacecraft and continue manufacture and qualification testing of production flight-configuration spacecraft. All major subsystems for the Command and Service Modules will be in the final stages of reliability and qualification testing.

Six production spacecraft will be delivered for ground testing, production of four flight test spacecraft will be completed, and three developmental spacecraft for flight tests will be delivered.

- **More for observatories**—The major surprise in the breakdown of the Space Science and Application program budget was the high cost of the *Observatory* spacecraft series.

The *Orbiting Solar Observatory (OSO),* with eight spacecraft in the program, will cost $76 million. The *Advanced OSO,* for which no total cost estimated was given, will push the cost of this series far higher.

Total price of the *Orbiting Astronomical Observatory* series is reported at $282 million for only five flights. The *Orbiting Geophysical Observatory (OGO)* program will cost $370 million for 11 flights.

While noting that the budget for the small *Explorer* satellite projects will drop in the next fiscal year, the space agency said it expects to launch four Magnetosphere and Interplanetary *Explorer* satellites per year through the end of this decade.

In the Astronomical and Astrophysical *Explorer* programs, about three per year will be launched through the end of the decade. ■

DETAILED BREAKDOWN OF NASA FY '65 R&D BUDGET REQUEST FOR OFFICES OF MANNED SPACE FLIGHT AND SPACE SCIENCES AND APPLICATIONS

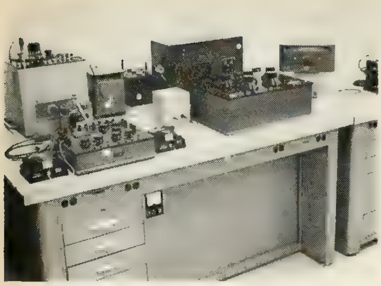
(in millions of dollars)

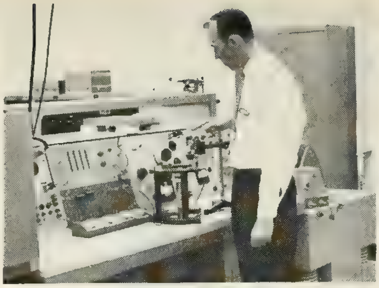
MANNED SPACEFLIGHT

	Fy '64	Fy '65
GEMINI	**383.8**	**308.4**
Spacecraft	252.3	168.9
Titan II	76.9	66.9
Atlas	6.3	19.5
Agena	26.8	24.9
Gemini support	21.5	28.2
SPACECRAFT	**870.9**	**945.8**
Command and service modules	508.3	520.5
Lunar Excursion Module	144.5	189.9
Guidance and navigation	91.5	83.8
Instrumentation and scientific equipment	5.6	7.5
Spacecraft support	121.0	144.1
ENGINE DEVELOPMENT		
H–1 engine development	9.1	8.2
H–1 propellants	2.0	1.6
RL–10 engine development	16.0	13.9
RL–10 propellants	4.0	4.0
F–1 engine development	55.3	55.1
F–1 propellants	7.0	9.0
J–2 engine development	48.4	47.6
J–2 propellants	8.3	14.0
SATURN I	**204.2**	**120.6**
S–1 stage	59.0	20.6
S–IV stage	82.1	55.4
Vehicle instrument unit	14.2	3.6
Ground support equipment	4.4	3.7
H–1 engine procurement	3.2	—
RL–10 engine procurement	4.9	—
Vehicle support	36.4	37.3
SATURN IB	**149.9**	**260.1**
S–IB stage	39.2	79.1
S–IVB stage	21.6	57.0
Vehicle instrument unit	14.2	28.4
Ground support equipment	33.0	31.5
H–1 engine procurement	8.0	12.4
J–2 engine procurement	6.4	11.0
Vehicle support	27.5	40.7
SATURN V	**609.6**	**988.4**
S–IC stage	218.3	271.6
S–II stage	134.6	189.9
S–IVB stage	95.6	126.8
Vehicle instrument unit	69.9	78.1
Ground support equipment	25.8	70.1
F–1 engine procurement	45.0	67.4
J–2 engine procurement	24.9	45.3
Vehicle support	75.5	139.2
APOLLO SUPPORT	**179.3**	**209.2**
Systems engineering	40.9	46.0
Launch operations and instrumentation	36.5	51.3
Mission control systems	52.5	41.4
Apollo space operation	2.9	21.6
Support technology	46.5	48.9
ADVANCED STUDIES	**22.1**	**26.0**
TOTAL	**2,600.0**	**3,011.0**

SPACE SCIENCE AND APPLICATIONS

	Fy '64	Fy '65
SUPPORTING RESEARCH AND TECHNOLOGY	**15.1**	**14.8**
Solar physics	2.2	2.2
Astronomy	2.6	2.6
Geophysics	8.8	8.5
Interdisciplinary	1.5	1.5
ORBITING SOLAR OBSERVATORY	**14.7**	**13.1**
Spacecraft	5.4	4.7
Experiments	5.3	5.6
Ground operations	0.3	0.1
Delta launch vehicles	3.7	2.7
ADVANCED ORBITING SOLAR OBSERVATORY	**4.1**	**9.0**
Spacecraft	4.1	7.0
Experiments	—	2.0
ASTRONOMICAL OBSERVATORIES	**47.7**	**51.0**
Spacecraft	30.4	31.1
Experiments	9.4	6.5
Atlas-Agena vehicles	7.9	13.4
GEOPHYSICAL OBSERVATORIES	**53.3**	**55.4**
Spacecraft	35.0	22.7
Experiments	9.1	9.9
Ground operations	1.4	1.9
Atlas-Agena vehicles	4.8	5.2
Thor-Agena vehicles	3.0	5.7
EXPLORERS	**34.2**	**31.9**
Atmosphere and ionosphere Explorers	7.7	5.3
Magnetosphere and interplanetary Explorers	5.6	6.8
Astronomical and astrophysical Explorers	1.5	7.0
Delta launch vehicles	11.7	7.5
Scout launch vehicles	6.6	4.3
Thor-Agena launch vehicles	1.1	1.0
SOUNDING ROCKETS	**17.1**	**15.0**
Experiments	9.0	6.0
Rocket procurement	2.9	3.4
Attitude control systems	1.6	1.7
Rocket development	0.3	0.4
Engineering support	0.6	0.5
Instrumentation	2.7	3.0
SUPPORTING RESEARCH AND TECHNOLOGY	**19.0**	**18.1**
Lunar and planetary science	12.3	11.5
Advanced technical development	4.4	4.1
Advanced studies	2.3	2.5
MANNED SPACE SCIENCE	**4.9**	**11.0**
Supporting research and technology	1.2	2.1
Manned satellite science	0.9	3.1
Manned lunar science	2.1	5.8
RANGER	**52.2**	**10.8**
Spacecraft	29.1	7.0
Experiments	5.7	1.4
Ground operations	6.2	0.4
Launch vehicles	11.2	2.0
SURVEYOR	**98.6**	**136.0**
Spacecraft	57.2	64.4
Experiments	4.7	11.6
Ground operations	4.7	6.0
Launch vehicles	32.0	54.0
LUNAR ORBITER	**20.0**	**49.3**
Spacecraft	20.0	31.6
Ground operations	—	2.2
Launch vehicles	—	15.5
MARINER	**59.1**	**54.1**
Spacecraft	27.3	25.1
Experiments	8.1	8.6
Ground operations	10.0	9.5
Launch vehicles	13.7	10.9
PIONEER	**17.7**	**21.1**
Spacecraft	11.0	7.9
Experiments	2.3	4.2
Ground operations	0.3	0.9
Launch vehicles	4.1	8.1
UNIVERSITY PROGRAM	**40.0**	**46.0**
Training	20.0	25.0
Facilities	12.0	10.0
Research	8.0	11.0
LAUNCH VEHICLE		
Supporting Research and Technology	**1.9**	**4.5**
Fluid behavior studies	0.5	0.5
Solid-state technology research	0.2	0.5
Vehicle system studies	0.9	1.5
Instrumentation	—	0.2
Propulsion systems technology	0.3	1.8
CENTAUR	**108.1**	**92.0**
Vehicle development	91.6	86.4
Engine development	2.0	0.3
Support services	10.4	2.6
Propellants	4.1	2.7
ATLAS FLOX DEVELOPMENT	**1.9**	**17.5**
Engine and engine testing	1.0	7.5
Vehicles and vehicle testing	0.9	7.0
Ground support equipment and services	—	1.5
Propellants	—	1.5
OPERATIONAL VEHICLE SUPPORT	**13.2**	**14.2**
Product improvement and production testing	6.5	7.8
Maintenance of ground support equipment	3.6	2.9
System engineering	3.1	3.5
BIOS SUPPORTING RESEARCH AND TECHNOLOGY	**12.1**	**11.8**
Exobiology (including sterilization)	5.2	5.0
Environmental biology	2.9	2.8
Behavioral biology	2.1	2.1
Physical biology	1.0	1.9
BIOSATELLITE FLIGHT PROGRAM	**8.5**	**19.2**
Study contracts	—	—
Spacecraft	6.0	10.2
Experiments	2.5	2.3
Ground support	—	0.2
Launch vehicles	—	6.5
METEOROLOGICAL SATELLITE SUPPORTING RESEARCH AND TECHNOLOGY	**6.9**	**6.6**
Synchronous meteorological satellite	0.3	—
Advanced meteorological system component development	2.9	2.0
Advanced meteorological sensor development	1.5	1.9
Meteorological systems research	2.2	2.7
TIROS	**16.8**	**5.8**
Spacecraft	9.8	0.5
Ground support	3.2	2.0
Launch vehicle	3.8	3.3
NIMBUS	**41.2**	**18.9**
Spacecraft A, backup and B	30.8	8.9
Ground support	9.4	6.6
Launch vehicle	1.0	3.4
METEOROLOGICAL SOUNDING ROCKETS	**2.9**	**3.0**
Development of small meteorological sounding rocket system	1.0	1.0
Large meteorological sounding rocket program	1.8	1.9
COMMUNICATION SATELLITE SUPPORTING RESEARCH AND TECHNOLOGY	**1.7**	**3.5**
Advanced passive satellite studies	0.5	1.0
Research, experimentation and development	1.2	2.5
ECHO II	**2.6**	**0.3**
Spacecraft	0.3	—
Ground operations and support	1.0	0.3
Thor-Agena launch vehicle	1.3	—
RELAY	**2.9**	**1.8**
Spacecraft	0.5	—
Ground operations and support	2.1	1.8
Delta vehicle	0.3	—
SYNCOM	**6.3**	**2.0**
Spacecraft	2.7	0.3
Ground operations and support	0.5	1.7
Thrust-augmented Delta (TAD)	3.1	—
EARLY GRAVITY GRADIENT EXPERIMENT	—	**5.0**
Spacecraft	—	5.0
ADVANCED TECHNOLOGICAL SATELLITE SUPPORTING RESEARCH AND TECHNOLOGY	**2.1**	**1.1**
Advanced synchronous satellites studies	—	—
Stabilization techniques	1.5	0.5
Propagation studies	0.3	0.3
Components development	0.3	0.3
ADVANCED TECHNOLOGICAL SATELLITES	**16.4**	**29.9**
Spacecraft	12.7	18.4
Ground operations and support	3.7	5.6
Atlas-Agena vehicle	—	5.9
TOTAL	**742.5**	**776.9**





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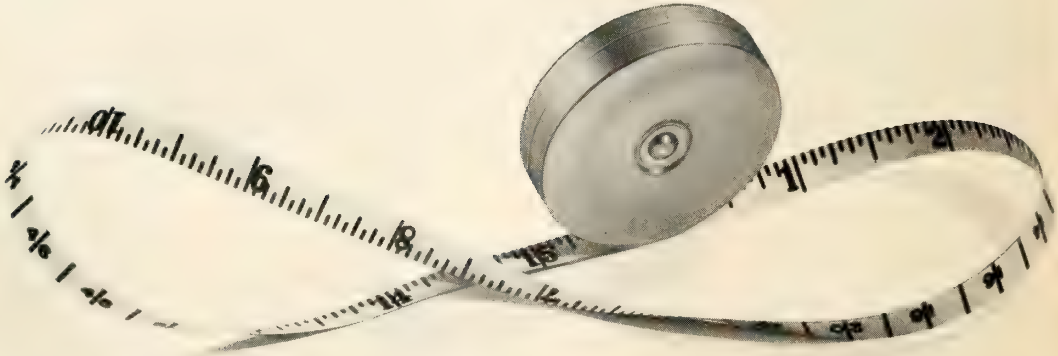
LOOK AT LOCKHEED...IN METROLOGY

Immeasurable improvement in the art of measurement



Technical Countdown

ELECTRONICS

Improved IR System Revealed

A new infrared tracker, developed by Diffraction Limited, Inc., reportedly operates with adjustable bandwidths between 2.5 to 5 microns or 5 to 15 microns, a resolution to 2.5 seconds of arc and a field of view up to 15 degrees. Designed by DLI scientists Dr. Adriaan Walther and Dr. Hendrik Sijgers, the new electrooptical system employs silicon and germanium lens elements in a four-element Petzval system to side-step the central obstructions associated with mirror systems. Believed ideal for use in air surveillance and ASW detection, the IR system, developers claim, could provide a field of view "exceeding one-quarter mile with a resolution of one inch at one mile."

Microelectronics Reliability To Be Studied

Librascope Div. of General Precision, Inc., reportedly is the frontrunner for NASA contract valued at up to $100,000 to perform a microelectronics study aimed at a determination of the physics of failure and reliability. The project, directed by Dr. John Walker, chief of communications and tracking, Electronics and Control Division, Office of Advanced Research and Technology, will cover both thin-film and semiconductor integrated circuits. The selected contractor's scope of work will include studies of criteria, device topology and circuit design, and require extensive data analysis.

Super-Power Ruby Laser Marketed

A 500-megawatt ruby laser that does not require use of an intermediate amplifier is to be marketed by Korad Corp., Santa Monica, Calif., a subsidiary of Union Carbide Corp. The laser, which has a possible application for missile tracking, will be priced at about $30,000.

Gemini Ground Displays Near Completion

First of 10 *Gemini* in-flight display systems will be delivered late this month. Each system, being built by Bendix-Pacific Division under a $5-million NASA contract, consists of five separate consoles for use by the command communicator, *Gemini* and *Agena* flight controllers (two identical displays), the aeromedical monitor and a maintenance and operation monitor. Two systems will be installed at the Manned Spacecraft Center in Houston and one will be installed at each of the following primary tracking stations: Carnarvon, Australia; Corpus Christi, Tex.; Canary Islands; Hawaii; Guaymas, Mexico; Wallops Island, Va.; and on the two tracking ships Rose Knot and Coastal Sentry.

Relativity May Cause ICBM Impact Error

The possibility that the special theory of relativity may be false and give an impact error of 0.15 nautical miles for a 90-degree ICBM trajectory has been suggested by Alton B. Hornback, General Dynamics/Electronics. The error would occur if ICBM velocity measurements were based on one-way Doppler. In two-way Doppler measurements, errors would cancel out. Hornback said a test on the special theory of relativity could be made by measuring the frequency of signals received from an atomic clock in a missile fired radially from the Earth at uniform speed. He said that a thorough review showed "the astonishing result that virtually all phenomena predicted by relativity are also predicted by classical or Maxwell-Lorenz electromagnetism." Chief difference between the theories is in their predictions for the one-way Doppler frequency shift.

ADVANCED MATERIALS

New Aluminide Coating Developed

An aluminide coating for columbium that won't drip or run, can be applied evenly to columbium alloys in any shape and will not create brittleness in the base metal has been produced by the Los Angeles Div. of North American Aviation, Inc. Already used on *Apollo* rocket engine nozzle extensions and *X-15* pressure rakes, the coating can be applied by spraying, brushing or dipping. Essentially consisting of a thin slurry of aluminum and ceramic powders suspended in an organic liquid, the coating is baked on in an inert-atmosphere furnace. At 1,900° F, the aluminum diffuses into the columbium forming columbium aluminide. Thus shielded, the alloy can withstand up to 2,600° F.

New Orleans Firm Boosting LH_2 Production

Executives of Air Products and Chemicals, Inc., Allentown, Pa., have announced plans for increased production capabilities at the firm's new complex now being built at New Orleans. Air Products recently was awarded a $19-million NASA contract to supply liquid hydrogen to the nearby NASA Mississippi Test Facility and also the Marshall Space Flight Center. The contract covers chemicals to be supplied between 1965 and 1970, in addition to the 30-tons-per-day liquid hydrogen facility. The New Orleans complex will have a cryogenic liquid plant with 1,000-tons-per-day production capacity of liquid and gaseous oxygen, nitrogen and argon. The firm is also planning to put other chemicals, which use hydrogen, nitrogen and oxygen, into industrial production. The hydrogen plant, which will feed the NASA needs, is expected to be in operation early next year.

Method Cuts Epoxy Curing Time

A means of reducing to two or three minutes the cure time for small epoxy, polyurethane and polyester parts is reported by Empire Research Corp., Cohoes, N.Y. The method uses an electronic heating oven that cures the parts, placed in silicon rubber molds, by means of molecular agitation. Heating is accomplished by converting 60-cycle a-c voltage to high d-c voltage. According to developers, the curing procedure requires little or no vacuum to perform de-aeration, since the casting compound is rapidly and thoroughly heated, reducing viscosity and eliminating air voids.

Simulator Will Test Space Plasma Phenomena

An ultra-high-vacuum space simulator, primarily designed for easy application toward the investigation of plasma attending missile and space probe flight, has been installed at the Naval Research Laboratory in Washington, D.C. Designed and installed by the Environmental Engineering Div. of Bethlehem Corp., Bethlehem, Pa., the 55-ft. steel vacuum tank has a four-stage steam-jet evacuation system that can pump down to one mm Hg pressure (up to 30 mi. simulated altitude). Accelerators are able to simulate velocities up to and beyond those of space probe re-entry vehicles. Thirty-eight ft. of the tank is available for research studies.

NASA Seen Blocking Electric Propulsion

by William Beller

NASA IS HOLDING BACK the nation's nuclear-electric propulsion effort, many industry and government experts are beginning to contend. Their argument may lead to a showdown battle between two propulsion systems—nuclear-electric and nuclear.

These experts say the situation may soon become critical. If it doesn't change for the better, they maintain, the United States in the 1970's could easily lose out to the Soviet Union in such post-*Apollo* projects as lunar basing and planetary exploration.

A Soviet military official now visiting the United States confirmed to MISSILES AND ROCKETS that his country is working on electric propulsion and that the problems are "very difficult ones," but he would not give any details. It is known, too, that the works of Demetrios Samaras, Air Force Office of Scientific Research scientist and author of fundamental texts on the theory of electrical propulsion, have been translated into Russian and are being used by Soviet space scientists.

The nuclear rocket, on the other hand, hailed by many engineers and systems managers—including Harry Finger, director of NASA's office of Nuclear Systems and Space Power—as the "logical follow-on to chemical propulsion," has been the most heavily financed of the space nuclear projects.

- **A prudent attitude**—Industrial proponents of electric propulsion are not eager to tangle with NASA's nuclear office because it holds the reins over virtually all this country's nuclear space work. Moreover, the Air Force's interest in SNAP 50—a 300-kw-to-1-Mw nuclear-electric energy converter for space—has been relegated to the Atomic Energy Commission.

Yet the advocates of a strong program in nuclear-electric propulsion are becoming more aggressive and asking:

—If the nuclear rocket is considered an easier technical development than nuclear-electric propulsion, a premise not universally accepted, why has it shown so little progress although nearly half a billion dollars has already been spent on its development?

—With nuclear-electric propulsion showing so much potential for growth, why is the field kept in the shadow of the nuclear rocket?

Funding between the two programs has been running at a ratio of about 10 to 1. There is less disparity in the proposed NASA Fiscal 1965 budget, in which nuclear rocket work is scheduled for $58 million plus facilities, but not including the eliminated RIFT and Kiwi programs. Nuclear-electric propulsion is scheduled for $13 million, with only a small amount for facilities.

Adding fuel to the fire, a NASA scientist close to the nuclear-electric program maintains that for prime propulsion, "thrustors for 500 kilowatts to a couple of megawatts can be ready by the early 1970's." He claims that nuclear electric systems for attitude control of satellites and for station keeping can be ready by 1966.

- **For lunar basing**—Nuclear-electric propulsion systems are said to be needed even for such short-haul work as supplying a lunar base, a program almost certain to accelerate after the first *Apollo* landing.

Recent studies by Avco Corp. and United Aircraft Corp. show that to deliver several hundred tons of material a month to the Moon would require many more *Saturn V* launch vehicles with a nuclear rocket or chemical stage than with a nuclear-electric stage.

Definition of Terms

THE NUCLEAR ROCKET engine, like that of the chemical rocket, is a thermal engine in which heat is added to a gas with a resulting gain in kinetic energy and propulsive force. The heat source is hotter in the nuclear rocket, but in both types the working gas is exhausted through an expansion nozzle.

In an advanced chemical engine, such as hydrogen and oxygen, the specific impulse is about 425 seconds. In a nuclear rocket engine, the specific impulse will probably not go much higher than 700 seconds, although it conceivably could go up to 900 seconds. Thus, the nuclear rocket is already being designed close to its performance limit.

The specific impulse for electric rocket engines covers the band from 700 seconds, where the nuclear rocket is in its prime, to beyond 15,000 seconds.

In electric propulsion, the heat energy from a nuclear or solar source is used to ionize atomic particles and accelerate them with electrical and magnetic fields to provide the very high particle velocities that give high impulse per unit mass of particle.

Thus, the considerations going into devising electric systems are much different from those for the nuclear rocket engine.

There are three types of electric propulsion systems:

—Electrothermal (resistojet and arc jet). Affords 700 seconds to more than 3,500 seconds specific impulse. Attains thrust by heating a propellant such as hydrogen or ammonia either by an electric arc or by passing it across heating coils and then expanding the propellant through a nozzle. Avco Corp. recently reached 3,500 seconds specific impulse in an arc jet test. Giannini Scientific Corp. attained specific impulses of greater than 7,200 seconds with a new type of arc jet.

—Electrostatic (ion). Affords 3,500 seconds to 15,000 seconds specific impulse. Thrust achieved by ionization of a propellant such as cesium or mercury by either passing propellant through a porous hot plate or by electron bombardment of propellant atoms and then accelerating resulting ion particles by electrostatic fields. Several such engines have demonstrated between 3,100 seconds and 10,000 seconds at

As the "freight" requirements increase beyond several hundred tons—which they will—the differential in the number of *Saturn V's* becomes even more significant.

The round-trip time for the nuclear-electric system would be about 30 to 40 days. Economy, not time, probably would be the most important factor for freight deliveries.

These studies verified earlier determinations that the cheapest way to carry a payload to the Moon is with a propulsion system having a specific impulse between 2,000 and 4,500 secs., satisfied only by the nuclear-electric system.

Three other separate studies—by Electro-Optical Systems, Inc., General Electric Co., and Jet Propulsion Laboratories—also show that the nuclear-electric propulsion system is far cheaper for lunar basing work than either the chemical or nuclear rocket. Because of this, Marshall Space Flight Center recently released RFP's for studies of spacecraft designs based on trajectory data for nuclear electric rockets.

● **First step—SNAP 50**—SNAP 50 is the only nuclear power conversion system currently under development in the U.S. that could provide prime power to electric thrustors for useful missions such as planetary and solar probes. It also offers the first power level that has growth possibilities to attain 8-15 Mw, suitable for manned planetary missions.

Rated at between 300 kw and 1 Mw, the SNAP-50 system is being designed to have a specific weight of 20-30 lb./kw with the ultimate goal of 10-20 lb./kw including the radiator but not the shielding, according to Col. Elwood M. Douthett (USAF), manager of the AEC's SNAP 50/SPUR office.

Hughes Aircraft Co., Electro-Optical Systems, Inc., TRW Space Technology Laboratories, General Electric and other companies.

—Electromagnetic. Provides 700 seconds to more than 15,000 seconds specific impulse. Attains thrust by ionizing a propellant such as argon, nitrogen or hydrogen by passing it through very intense electrical discharge or inducing a high electrical discharge in propellant; propellant is then accelerated by a force that results from interaction of an electric and magnetic fields. This method, already showing specific impulses up to 10,000 seconds, has been demonstrated by General Dynamics/Astronautics, General Electric, Avco Corp., Space Technology Laboratories and NASA's Langley and Lewis Research Laboratories.

The SNAP 50 power level, even with specific weights of 20-30 lb./kw, will provide a nuclear electric propulsion system capable of delivering payloads several times greater than those obtained with any chemical- or nuclear rocket-propelled spacecraft for many space science missions.

For the lunar freight mission, a nuclear-electric power package of between two and four megawatts would be needed—several times the output of SNAP 50. Thrustor for such a lunar mission would be the arc jet or some electromagnetic device such as an MHD accelerator. Avco has already demonstrated 2,200-sec. specific impulse at 200 kw from a radiation-cooled arc jet.

The requirement for power such as SNAP 50 could give has not been firmed up in NASA or in the Air Force as fast as the AEC had thought it would, according to Douthett. For this reason, he said it is difficult for the Commission to give as much support to SNAP 50 as it at one time hoped it could. "But I feel if someone at NASA would hold up his hand and say we need SNAP 50 at time *t*, we could build the solid technical base we need."

Douthett claims that no breakthroughs are needed to get a SNAP 50. "I don't see any difficulty we would have either technically, politically or financially once we got the go-ahead," he said. He feels the AEC could have a prototype SNAP 50 unit operating in space in 1972. "In 1975, we'd be ready for missions. Funding, not technical problems, limits SNAP-50 development."

Finger estimates that Project Rover will cost close to $2 billion, $450 million of which has already been spent. At the same time, he estimates that it will cost only about half as much—$1 billion—for a 300-kw SNAP 50 unit, the same figure suggested by Douthett.

● **Uses of high space power**—Douthett sees important missions for SNAP 50:

—*Unmanned planetary probes.* Douthett said that studies show that planetary exploration probes of Mars, Venus and Jupiter can be performed most economically by nuclear-electric means. He said, furthermore, that unmanned spacecraft scientific probes—such as solar and out-of-the-ecliptic—are highly attractive missions for electric propulsion. (M/R, Nov. 25, p. 74.)

—*Power for a lunar base.* NASA asked the Army Corps of Engineers to look into the power requirements for a lunar base, and the Engineers, in turn, gave a corresponding contract to Westinghouse Electric Corp. Initially, the power demand is expected to average out less than 100 kw, but after a few years the demand is expected to approach a megawatt. NASA suggests planning the initial base for 1973.

—*Military space vehicles.* Although the Air Force is calling for only 20-30 kw for its *Manned Orbiting Laboratory* (*MOL*), scheduled to orbit in three or four years, the follow-on probably will call for far greater amounts of power —for high-resolution radar, for example. The military has a history of never having enough electrical energy at hand. For instance, about 462 kva are used on the B-52, although the craft left the drawing boards with a requirement for only 60 kva.

● **Nuclear electric has problems**—Finger affirms "chemical and nuclear rockets will provide any programs we need."

He backs his argument by noting that "the power system for prime electric propulsion is a long way from being developed or even designed with confidence."

The principal people pressing for prime electric propulsion are the thrustor people, according to Finger. "They don't seem to realize the problems of the power unit, nor perhaps of the thrustor unit itself." He added that "we don't know how to operate a system for 10,000 hours, a requirement for nuclear-electric generated thrust."

He is calling for more basic data for the nuclear-electric field. "For example, we have to have the basic characteristics of potassium and sodium vapors. Only now are we getting boiling heat-transfer data at the temperatures we want."

Finger observed, though, "timing is the only thing against electrical propulsion." He said he would be "deeply troubled without a strong program in the field of nuclear-electric propulsion." He added that systems must be tested for feasibility. "It is much cheaper to find out if there is feasibility right away than to spend years struggling on a low-grade program."

● **So has the nuclear rocket now**—Finger failed to mention the many problems of the nuclear rocket—such as burn time in the reactor, erosion in the reactor, high cost, materials problems, re-starts in space, low mass ratio, ground support equipment problems, and performance decrements.

It should also be noted that mission analysts and NASA centers responsible for performing the missions, particularly at JPL and Marshall, in addition to thrustor experts, are calling for more effort on nuclear-electric propulsion.

Furthermore, if it were now known how to operate a nuclear-electric system for 10,000 hours, there would be no need for the present nuclear-electric effort—just as there would be no need for current research on the nuclear rocket if one were operational. ■

Advanced Saturn Guidance Platform Flies on Successful Saturn I SA-5

First all-beryllium pre-production model rides as open-loop package; gas-bearing inertial elements used throughout design

by Michael Getler

FIRST PRE-PRODUCTION MODEL of the ST-124 stabilized inertial platform, destined to guide future *Saturn IB* and *V* vehicles, was carried aloft as a passenger aboard the highly successful *Saturn I SA-5* launch vehicle from Cape Kennedy on Jan. 29.

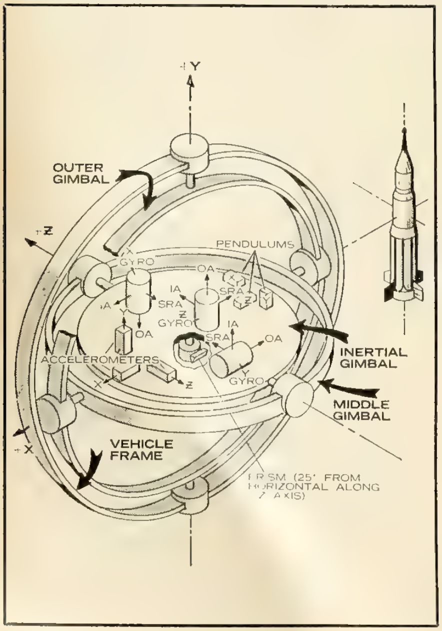
The platform, carried in *SA-5's* Instrument Unit (IU), was operating in an open-loop mode without exercising actual control over the launch vehicle. For *SA-5*, an earlier-developed ST-90S guidance and control system served as the active system.

Thirty-three channels of telemetry data were provided for in-flight performance and environment measurement on the ST-124 package.

Prototype versions of the ST-124 have flown previously, also in open-loop modes, aboard *SA-3* and *SA-4*. Although designed for *IB* and *V* vehicles, the platform also will get closed-loop operating checkouts in upcoming *Saturn I* launchings.

At a press conference following the *SA-5* launching, Dr. Wernher von Braun, director of NASA's Marshall Space Flight Center, said that a quick look at telemetry data indicated the platform had performed very well and that the ST-124 probably would get its first active guidance role in the next *Saturn* shot, scheduled for April (M/R, Feb. 3, p. 18). Actually, ST-124 is likely to play only a limited closed-loop role, probably generating engine cut-off signals, aboard *SA-6*.

First flight in which the platform is



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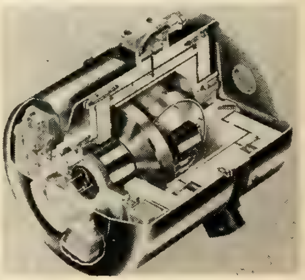
1—Schematic of three-gimbal version of ST-124 shows location of inertial components mounted to inner gimbal, and prism gimbal just below stable element. 2—Cutaway of single-degree-of-freedom gyro. 3—Cutaway of pendulous gyro accelerometer. 4—Technician checks platform in final inspection series. 5—Complete platform encased in steel dome covers undergoes calibration check on Bendix turn-tilt stand.



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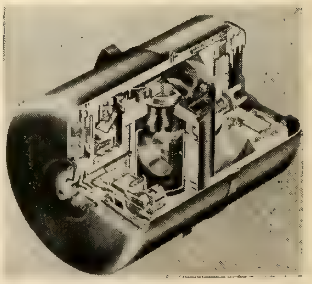

expected to exercise complete active control is *SA-7*, due to be made in about six months. Both *SA-6* and *SA-7* will boost *Apollo* boilerplate models. The new system is also expected to be used for the following two *Saturn* launchings (*SA-8* and *SA-9*), in which *Meteoroid Detection Satellites* will be lifted into Earth orbit.

The *Saturn* stabilized platform will operate in conjunction with two other major subsystems—a general-purpose digital guidance computer and an analog control computer with associated sensors and actuators—to form the complete *Saturn* guidance and control system. An on-board data adapter handles interface requirements. As a system, *Saturn* G&C is viewed as a significant broad advance in guidance philosophy and execution (M/R, Oct. 7, p. 57).

● **NASA-Bendix team**—The concept for the ST-124 platform and responsibility for primary design and development has been retained in-house by NASA's Astrionics Laboratory, in particular the Inertial Sensors and Stabilization Div., at the Marshall Space Flight Center, Huntsville, Ala.

Fabrication of the platform, its inertial elements and associated electronics is being undertaken by Bendix Corp.'s Eclipse-Pioneer Div., Teterboro, N.J. Bendix engineers are also providing some detail system design in addition to production design for inertial componentry.

Saturn guidance has meant considerable business for Bendix thus far, and this promises to continue, possibly even into post-*Saturn* vehicles.

Late in January, NASA awarded Eclipse-Pioneer a contract for 29 *Saturn IB* and *V* platforms, associated services and test equipment. The value of the cost-plus-incentive-fee contract probably will exceed $25 million. The program is expected to be spread over four years, providing flight systems and spares for all currently planned *Saturn IB* and *V* launchings. Prior to the recent negotiations, Bendix, since 1961, had received other *Saturn I* and advanced *Saturn* guidance awards totaling just under $25 million.

NASA sources also told M/R that the guidance platform for any post-*Saturn* vehicles, such as *Nova*, that might be funded in the future will almost certainly evolve from the ST-124.

The high reliability that NASA hopes to achieve with the ST-124 stems not only from the choice of components and materials, but also from the fact that the Huntsville-Bendix team has been together, largely intact, for the past five years dating back to development of the *Pershing* missile platform under what was formerly the Redstone Arsenal team at Huntsville, with Eclipse-Pioneer supplying the hardware and some supporting R&D.

● **Gas bearings and beryllium**—Though *Saturn's* is basically a different platform design from *Pershing's*, much of the *Saturn* inertial componentry, in particular the gyros, have evolved from the *Pershing* design. For all the ST-124 inertial elements, it was decided, as it was in the case of *Pershing*, to use gyro and accelerometer components on gas bearings rather than fluid-type floated devices. In support of this, program officials cite the *Pershing* platform record of no in-flight platform failures in the 72 flights made with the missile to date. In-plant rejection rate on *Pershing* components mounted on gas bearings is said to be less than 3%, with field rejection rates "negligible."

Use of gas-bearing devices, according to project engineers, has also cut down on the number of electronic components, particularly through elimination of electronic compensation and temperature-control subsystems associated with fluid-floated devices. Engineers say the ST-124 requires only about 1,000 discrete components—resistors, transistors, and condensers—as opposed to 5-6 times that figure for designs using fluid-floated inertial elements.

The associated electronics are housed in stacked modules attached to motherboards. No integrated circuitry is included in the design, although this is being studied.

Other major improvements in the ST-124 have resulted from the widespread use of beryllium throughout the platform, another technique harking back to early *Pershing* days, when Bendix assisted Redstone in proving the feasibility of using beryllium for gyro cans.

NASA and Bendix engineers say the pre-production beryllium model of the ST-124 aboard *SA-5* becomes the first "really all-beryllium platform" to be flown (a beryllium platform is also reportedly being built for use in the *Minuteman* ICBM).

All structural members and all componentry—with the exception of gyro wheels (monel), magnetic elements, and

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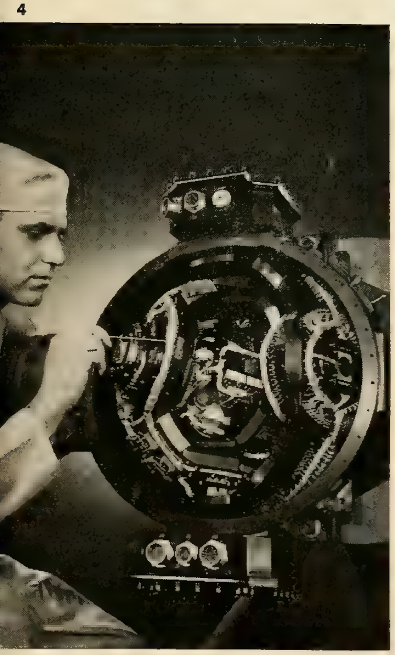

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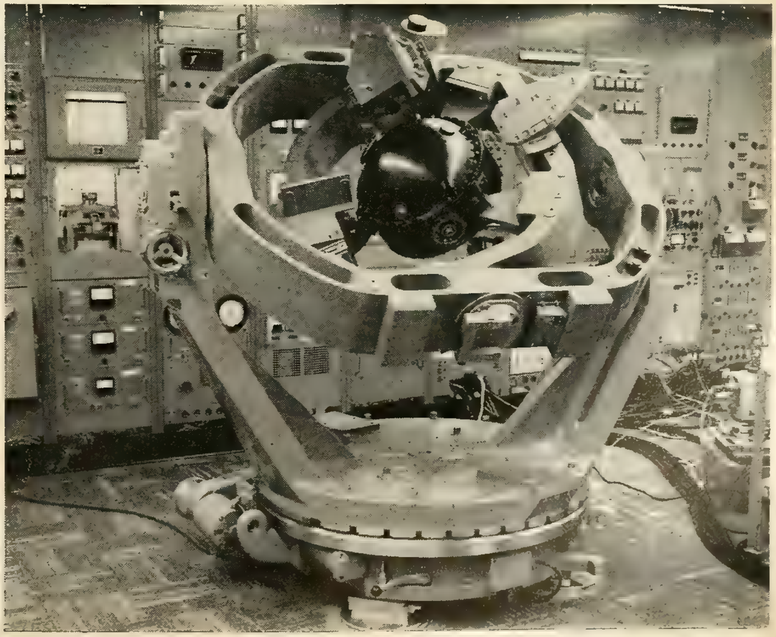


accelerometer encoders—use beryllium. The use of this material imparts significant improvements in stability, heat transfer and cold-soak capabilities, in addition to weight savings. Another advantage of its use is the high (130 cps) primary resonance frequency for the inner gimbal member. This frequency is is above the vehicle body-bending frequency and structural resonance points, eliminating platform perturbations from those traditional sources. This is especially important, since the platform system is rigidly mounted (with no shock-mounts used) to the frame of the vehicle.

NASA scientists say the expected ST-124 performance will be better by a factor of 10 than what the state of the art was two years ago, when ST-124 effort got underway.

- **Platform design**—The ST-124 uses an outside gimbaling scheme and can be configured with either three or four gimbals. Use of four gimbals (the outermost structure serves as the redundant yaw gimbal) provides unlimited angular freedom about all axes and avoids potential gimbal lock problems. The four-gimbal configuration is expected to be used in all *Saturn V* flights in which complex rendezvous and maneuvering capabilities are required. The three-gimbal version would provide limited (± 60 deg.) yaw (middle) gimbal freedom. According to NASA, the three-gimbal version will be used predominantly on the *IB* flights. The systems to be test-flown aboard the *Saturn I* vehicles will all be four-gimbal designs. Bendix is manufacturing a "gimbal kit" that will allow NASA to go from one configuration to the other in about one week's time.

The spherical ST-124 platform measures 21 in. across, and weighs about 110 lbs. in the three-gimbal configuration. Addition of the fourth gimbal adds another 15 lbs. System requires peak power of 200 watts dc, and normal running power of about 63 watts dc.

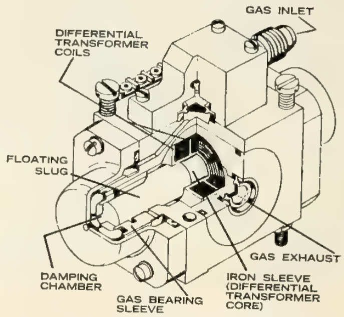
NASA engineers point out that the ST-124 is actually a five-gimbal system when the dual-prism pre-launch azimuth alignment system is included. With this system (M/R, Sept. 30, p. 42), not only is preflight azimuth laying made highly accurate, but the ability to update the firing azimuth while on the launch pad removes firing time and launch window restrictions due to countdown holds. The prisms are mounted on a small gimbal carried on the bottom side of the inner gimbal. The prism gimbal has 360 degrees rotational freedom.

Mounted to the stable inner element, or inertial gimbal, of the ST-124 are three single-degree-of-freedom gyros, three pendulous-gyro-accelerometers, and two pre-flight leveling pendulums.

- **Components**—The gyros used in the ST-124 weigh 2 lbs. each and are 3 in. wide and 4 in. long. The gyro wheel is supported in the beryllium cylinder, which, in turn, is supported by the hydrostatic gas-bearing with both radial and axial centering. Gas consumption is 1,100 std. cc's per min. Ribbon-type flex leads provide power transmission to the cylinder. The gyro cylinder machining roundness and taper tolerances are said to be less than 20 micro-inches, with squareness tolerances to the cylinder axis about 20 micro-inches per inch. The gyro's angular momentum is reportedly 2 x 10^6g cm^2/sec.

The gyros use shorted-turn, variable reluctance-type magnetic pick-offs, with a 4.8-kc excitation frequency.

The accelerometers use the same gyro design as the ST-124 platform gyros and have an angular momentum figure of 10^5g cm^2/sec. The gas consumption for the accelerometers is slightly higher than for the gyros, about 1,200 std. cc's per min. Accelerometer pendulosity is reported as 20 gram centimeters, and its scale factor as 300 meters per sec. per revolution of the output axis. The 2.5-lb. device, packaged in a 5 x 3.5-in. beryllium cylinder, has a digital-encoder (mounted on the accelerometer head) output with a bit count of 0.05 meters per sec. per bit.


GAS INLET
DIFFERENTIAL TRANSFORMER COILS
FLOATING SLUG
GAS EXHAUST
DAMPING CHAMBER
GAS BEARING SLEEVE
IRON SLEEVE (DIFFERENTIAL TRANSFORMER CORE)

DRAWING shows major components of gas-bearing pendulum, third element mounted on inner gimbal.

The pendulums, also gas-bearing beryllium-structured devices, have an accuracy of about ±5 arc sec., according to Bendix, and are used solely for pre-flight leveling and alignment. The units perform no in-flight function. Essentially, they consist of a magnetic element suspended on a gas bearing inside a linear differential transformer.

The ST-124 also contains a unique resolver chain to provide three-axis attitude error signals for use by the *Saturn* control system. Three programmed command resolvers mounted externally in the inertial data box, part of the associated electronics that Bendix supplies, and four unprogrammed resolvers, one mounted in each of the gimbal pivots, make up the chain.

The resolver chain, in effect, compares the actual vehicle coordinates, measured by the pivot resolvers, with those programmed inputs, or Eulerian angles, received from the inertial data box resolvers and shapes the proper degree of attitude correction. The chain is unique, NASA points out, in that each resolver essentially is made to transform two axes simultaneously instead of one, which is normally the case. This allows three steering signals to be generated by one chain instead of two. The double duty is accomplished by exciting the chain with two inharmonically related frequencies, using filter separation for demodulation to error signals. When these error signals are driven to zero, the actual vehicle coordinate system is aligned with the desired vehicle coordinate system and the *Saturn* thrust acts in the optimum direction.

In addition to the resolver chain, each gimbal pivot also contains a multi-speed resolver, with an accuracy of 10 sec. of arc, which is used as a separate, or possible back-up, digital sensing device.

Bendix engineers also point out that dc torque motors are used throughout the ST-124 system. The main gimbals have a maximum torque capability of 200 in.-oz. Engineers also note that transmission between the platform and the associated electronics is all dc.

- **Well tested**—In addition to the flight testing carried out to date, the ST-124 has been through sled tests at Holloman AFB, undergoing linear accelerations of 8.5 g's and vibration environments of 25 g's. No malfunctions and good acceleration correlation were reported. The system is actually designed to withstand thrust levels in excess of 20 g's and vibration levels of 2.5 x 10^{-2} g^2 per cps.

Inertial sensors reportedly operate over a 100°C spread, withstanding ±10°C temperature variations without degradation. Total system performance variation at upper and lower temperature limits is reportedly less than 2:1 from its designed ambient, according to Bendix. The unit can be stored at temperatures from —60° to +150°C.

Component acceptance tests and calibration are done at Huntsville and the components are shipped back to Bendix for systems installation. The entire system is retested at Huntsville in a *Saturn* IU, then removed and shipped to Cape Kennedy where it is tested again.

The platform can be drift-tested at the launch site in six different gyro and accelerometer positions with respect to local vertical. ■

Flight Research Center, AF Press for Hypersonic Research Vehicle

Favorable decision could come this year on $500-750 million program based on LH_2-burning turbo-ramjet; debate within NASA

by Russell Hawkes

NASA's Flight Research Center, Edwards, Calif., and the Air Force are campaigning for funds to develop an air-breathing Hypersonic Research Vehicle (HRV) that will focus technology on the development of recoverable space boosters, *Aerospace Planes*, true hypersonic interceptors, and Mach-8 successors to the supersonic transport.

There is thought to be a reasonably good chance of an affirmative decision on the HRV during 1964.

As it now stands, the proposal is to build two 85,000-lb., turbo-ramjet-powered vehicles. The cost of the program is estimated variously from $500 million to $750 million.

- **NASA split**—The impressive pricetag is at the root of intramural debate within NASA over whether to press on with the program at this time. Longley Research Center technologists have contended that it is not economically feasible to spend that sort of money on a research vehicle and that a military mission must be found to justify the program. However, they are reported to be looking more favorably on the HRV since the completion of studies indicating that a mission-oriented vehicle apparently would weigh more than 500,000 lbs. and would cost far more than the highest estimate for the HRV.

Langley researchers are just beginning to operate a pair of new Mach-8 high-temperature facilities, and they would like to apply these to the problem before being committed to a research aircraft design. They are also trying to get funds for a *Scout* rocket system to be used as a ramjet test bed for the HRV performance region; they want to see what becomes of this effort before proceeding on the HRV.

Ames Research Center has asked for another six to eight months to study the proposition before taking a position. Scientists there agree that there should be another research airplane, but they would prefer first to see the outcome of a number of their own laboratory investigations related to HRV problems.

The Air Force, waiting for NASA to make up its mind, is the program's strongest advocate.

The trouble with attempting to develop a technologically advanced vehicle without an intervening research vehicle program is that the high technical risk, uneven advance of component technology and resulting high development costs discourage government support and the program is allowed to starve by degrees.

- **Needs**—Flight Research Center lists three major areas of development requiring the HRV:

—An air-breathing propulsion system capable of operating in the Mach 6 to Mach 9 range.

—Lightweight structure capable of withstanding the prolonged heating and high dynamic pressures encountered by a hypersonic cruise vehicle.

—An airframe with high aerodynamic efficiency—lift-drag ratio between 6.0 and 9.0.

De Beeler, assistant director of FRC, told M/R that when the HRV design is finalized, it will look much like the model FRC is now showing industry. However, wind-tunnel tests of the model have not yet started and there are sure to be at least minor changes in such details as the size and location of vertical stabilizers and the shape of engine inlets. Its range would be about 3,000 mi.

- **Power plant**—Heart of the proposed HRV is its liquid hydrogen-burning turbo-ramjet engine, which should generate betwen 55,000 and 70,000 lbs. of thrust. An attempt will be made to develop an engine in which flow is supersonic. The planned speed range between Mach 6.5 and Mach 9.0 is now regarded as the transition zone in which supersonic burning begins to be more efficient than subsonic burning.

FRC is estimating a four-year lead-time for the engine—and six years from go-ahead until the first flight of the HRV. The center is stressing development of the turbo-ramjet engine to minimize the temptation of economy-minded administrators to build the research craft around some existing rocket engine. FRC engineers are sure this would materially reduce the value of the program.

One of the early steps in engine development will be operation of a liquid hydrogen-burning ramjet engine on *X-15* flights planned in 1966 or 1967.

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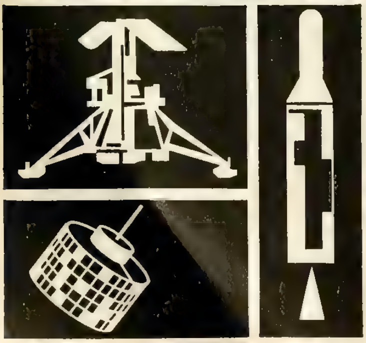


There are also plans to use the *X-15* as a test bed for supersonic combustion experiments and HRV structural tests specimens will be installed as *X-15* wing panels.

The development of the HRV engine would really be completed during the flight-testing of the vehicle and not before. Beeler told M/R it probably will not be possible to provide the HRV with a flight-rated engine, as has been done in all past development of manned systems.

The rule has been that an engine was ready for flight-test only after 30 accurately simulated missions in ground test facilities. The enormous flow rate and difficult environment of the HRV turbo-ramjet make this completely unattainable, in the opinion of FRC engineers.

A proposal has been heard to build an immense facility at the Air Force Arnold Engineering Development Center in Tullahoma. Tenn. which would be able to run-full scale tests on such an engine, but their duration could not be more than five minutes. FRC engineers conclude that it would take seven years and an astronomical sum of money to flight-rate the engine at that pace.

- **Another way**—If the HRV is used as a flying wind tunnel for the development of its own engine, the test runs can be from 30 minutes to an hour and a half long. Such a program can be conducted safely by verifying the integrity of the engine up to the limits of existing ground facilities and extending the performance envelope in easy increments until it has been completely explored during flight tests.

Beeler denies that this would be a radical way to conduct the program. He points out that only the engine designer has had the luxury of pre-flight rating his product in the past. The airframe designers have always had to complete the development of the vehicle during the flight test program. Beeler reports that the leading edges of the *X-15* were considerably modified twice since the first flight. Had they been operated up to their design Mach numbers before the modifications, the research craft would have been destroyed in flight.

Ground facilities exist or are being prepared which can completely test the turbo-ramjet to Mach 4.5. The ramjet duct can be subjected to realistic temperatures and pressures in ground facilities with the turbojet section blocked off and the rotor fixed. Since this probably is how the engine would be operated at the top of its performance envelope anyway, flight rating would consist mainly of demonstrating and modifying the cycling of the system and its controls in all possible environments.

Automatic control of the engine air inlet, exit nozzle, and fuel flow will be essential. Such a system has not yet been developed but will surely be available in time for the HRV, since it is regarded as necessary for the Mach 3 supersonic transport.

- **Structure**—The airframe structure of the *X-15* has been subjected to the hypersonic environment, but it was designed merely to survive and is much less efficient than the planned HRV structure. Structure of the HRV should not weigh more than 20% of maximum take-off gross weight; *X-15* structure constitutes about 35%.

The problem of developing a suitable lightweight structure for hypersonic cruise missions lasting two or three hours is complicated by the use of liquid hydrogen fuel, which makes a very steep thermal gradient between a skin that may be as hot as 3,000°F. and the fuel at —435°F.

Beeler said industry has put forward a number of structural concepts, most of them quite conservative. Fancy sandwich structures are less favored than conventional built-up ones because of worries about the difficulty of repairing the former or modifying it in response to the new learning extracted from the program.

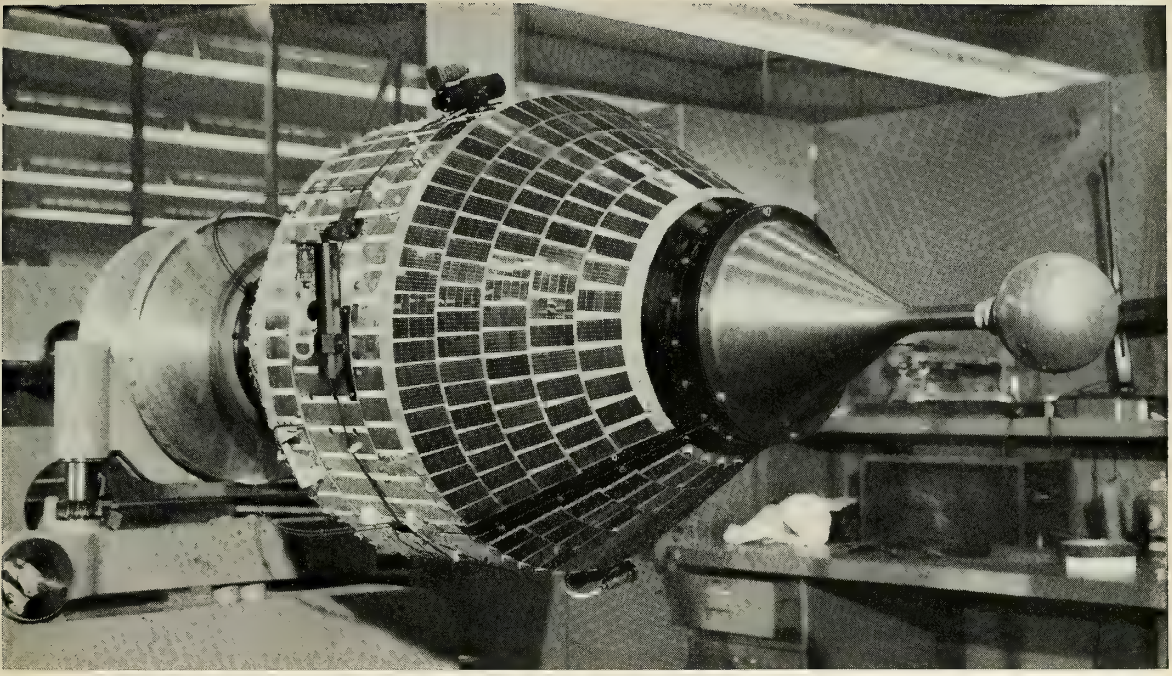
It will be necessary to use exotic materials in the hypersonic environment. Of these, molybdenum is the leading contender. A major contribution of the HRV would be the demonstration that it is now possible to use moly alloys as a primary structural material.

The structure selected must incorporate enough insulation to minimize boil-off of the liquid hydrogen fuel. There is a trade-off to be made between the weight of this insulation and the weight of make-up fuel required if insulation is absent or reduced.

The presence aboard of liquid hydrogen is not without its benefits. It can be used as a coolant for key components like the landing gear, permitting the use of conventional wheels and tires rather than skids of the sort installed on the *X-15*. This is a necessary provision, since NASA engineers want the HRV to take off, land and cruise like an ordinary airplane.

It is also likely that the engine inlets and the hottest leading edges would have to be cooled. This might impose a design penalty on the otherwise attractive specifics of the propulsion system.

The relatively high aerodynamic efficiency of the HRV is intended to make possible three- and four-hour missions. However, much useful information for the development of air-breathing recoverable boosters could be collected on missions lasting no more than 30 or 40 minutes. ■



IONOSPHERE EXPLORER, with ion composition probe at right, is shown minus antennas in environmental testing.

Ionosphere Explorer To Complement Density Data Supplied by Alouette

by Lawrence J. Curran

THE SECOND SATELLITE in NASA's Topside Sounder program—officially designated *Ionosphere Explorer*—will soon join its Canadian "cousin" *Alouette* in orbit to study irregularities in electron distribution in the ionosphere's F layer.

Spokesmen at Goddard Space Flight Center, which has general and administrative supervision of the Topside Sounder program and this satellite, say the launch will take place no later than the end of the first quarter of the year from Point Arguello, Calif.

A four-stage *Scout* will boost the *Ionosphere Explorer* (formerly called *S-48*) into a nearly circular polar orbit with an apogee of about 630 mi. Inclination will be 80 degrees. The payload will weigh approximately 97 lbs.

The Central Radio Propagation Laboratory (CRPL) of the National Bureau of Standards, Boulder, Colo., designed the two experiments aboard the *Ionosphere Explorer*, and Airborne Instruments Laboratory (AIL), Deer Park, N.Y., built the satellite and instrumentation.

- **Experiment details**—Extra time afforded by program slippages has been used to optimize the experiments aboard the satellite, Goddard's John E. Jackson told MISSILES AND ROCKETS. Jackson is project manager for the *Ionosphere Explorer*.

The most recent delay, causing launch slippage from the last quarter of 1963, resulted from difficulties encountered with the *Scout* booster.

The two experiments are the sounder and an ion composition probe (spheroid appendage in photo). The latter was "borrowed" substantially from the British-designed *UK-1* or *Ariel* international ionospheric satellite.

The sounder consists of six 8- to 45-watt transmitters that will emit pulses sequentially at six fixed frequencies from 1.5 to 7.22 mc. RF pulse duration is 100 microseconds.

- **International cooperation stressed**—Data obtained by the *Ionosphere Explorer* is expected to complement that being delivered by the Canadian-developed *Alouette*. The latter is generally considered one of the most successful scientific satellites ever launched. It is the result of the fruitful association of NASA with the civilian Canadian Defense Research Board.

Alouette was launched by NASA Sept. 29, 1962, aboard a *Thor-Agena B* from Point Arguello. It is still transmitting from its near-circular orbit, and has roughly the same 630-mi. apogee planned for the *Ionosphere Explorer*.

Chief difference in the data from *Alouette* and that anticipated from the *Ionosphere Explorer*, Jackson says, is that *Alouette* gives a precisely defined

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vertical profile of electron density in the F layer, and the AIL-built satellite is expected to deliver a better horizontal profile.

The close international cooperation shown in the Topside Sounder program first allowed Canadian scientists to profit from U.S. experiments early in what was then the *S-48* program.

Two launches of simplified versions of the *Ionosphere Explorer's* sounder system were conducted from Wallops Island, Va., in 1961. These were sounding rocket shots into the F layer, proving the sounder's component feasibility and returning data that aided the Canadians in refining experiments earmarked for *Alouette*.

Now the telemetry information being gathered from *Alouette* has permitted the Goddard-CRPL-AIL team to adjust the *Ionosphere Explorer* so that it might anticipate and further study certain irregularities in electron distribution "seen" both by *Alouette* and in the Wallops shots.

The *Ionosphere Explorer* sounder should provide data on these phenomena:

—Electron density in the F layer of the ionosphere, which extends from about 180 mi. to 700 mi. altitude.

—Variations of these ionized-particle densities diurnally, seasonally, and with changes in latitude and geomagnetic disturbance.

—Plasma resonance frequency near the sounder.

—Cosmic noise intensity in the frequencies covered.

• **"Spread F" mystery**—Besides the above, Jackson and E. Dale Nelson, assistant project manager at Goddard, hope the sounder can give them more data on the phenomenon known as "Spread F."

Spread F has been charted for some time as a result of bottomside soundings. It has been generally defined by Jackson and colleagues at CRPL and AIL as "the reflection of radio waves from the F region, which, for periods lasting from a few minutes to several hours, cease to be well defined over a relatively narrow interval. Instead, a large number of scattered returns at various ranges are observed." This, says Jackson, is one of the F-layer irregularities the *Ionosphere Explorer* is designed to probe more extensively.

Goddard scientists also hope to make better use of the cosmic noise data that is automatically captured by such sounders. The Goddard *Ionosphere Explorer* team suggested certain changes to CRPL that have resulted in a much better signal strength calibration on the sounder receiver that might give them some clue as to the origins of the noise.

• **Ion probe**—The *Ariel*-type ion composition probe should fill some data gaps left by *Alouette* at satellite altitude regarding ion temperature and composition. *Alouette's* vertical density profiles are considered good, but Jackson says the Canadian satellite doesn't have the designed-in capability to properly separate temperature and composition data.

The additional information expected from the U.S. satellite should help solve space vehicle communications, tracking and guidance problems peculiar to the ionosphere.

The ion composition probe would not have been aboard if the *Ionosphere Explorer* had been launched on schedule. Nor would the satellite's frequencies have been lowered from the earlier specified range of 2.85-8.57 mc. The latter change was required because of the drop in solar activity the satellite will encounter, since it will be in orbit during some of the 18-month International Quiet Solar Years. Lower electron density will result, Jackson says.

One set of dipole antennas had to be lengthened to cover the *Ionosphere Explorer's* lower frequencies. In all, the satellite will carry three pairs of motor-driven antennas of the type originally developed by The de Havilland Aircraft of Canada, Ltd., Toronto, for the *Alouette*. Two sets each measure 62 ft. from tip to tip, and the third pair is 122 ft. long.

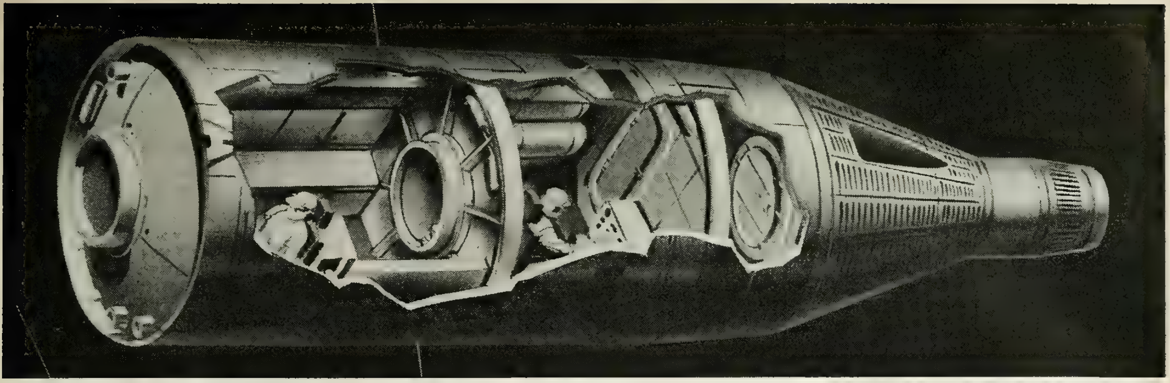
• **New U.S.-Canada rapport**—All environmental testing of the *Ionosphere Explorer* systems was done either in-house at Goddard or out-of-house under Goddard contract and supervision.

Tracking responsibility for the *Ionosphere Explorer* will rest solely with Goddard, while telemetry data will be gathered by essentially the same network that *Alouette* uses. This system includes 13 ground stations involving three nations: three stations constructed in Canada for *Alouette*, along with two British stations—one at Singapore and the other in the South Atlantic; in addition, NASA's Space Tracking and Data Acquisition Network (STADAN, formerly Minitrack) will participate.

The spirit of international cooperation originally engendered in 1960 between Canada and the U.S. at the outset of the old *S-48* program will be continued by a recent NASA-Canadian Defense Research Board agreement to launch four more upper-atmosphere research satellites between 1965-70.

A second *Alouette* is included in the agreement, and its exploration will undoubtedly be enhanced by the U.S.-Canadian achievements to date.

The jointly funded program has been characterized by Dr. Hugh L. Dryden, NASA deputy administrator, as representing "the most advanced program of international cooperation in space research" yet to be developed. ■



PRELIMINARY CONCEPTION of Air Force's Manned Orbital Laboratory, development of which will be managed by Space Systems Division, Air Force Systems Command. MOL will consist of a cylindrical spacecraft mated to a modified Gemini capsule.

Air Force Seeks Winged Supply Vehicle To Link with MOL

by Heather M. David

San Antonio, Tex.—The Air Force is now pressing for a winged ferry vehicle for rendezvous missions with the *Manned Orbiting Laboratory (MOL).*

Although the Defense Dept. has not given official sanction, Lt. Gen. James Ferguson, AF deputy chief of staff for R&D, said "we visualize such a ferry craft to be a lifting body with some maneuverability in the atmosphere for precision landing. Undoubtedly it would be able to carry more than two men, as well as be a logistics carrier."

The deputy chief, who was one of *Dyna-Soar's* strongest proponents, said that *Gemini* would be used in any initial rendezvous program.

Air Force spokesmen said that possible *Gemini* rendezvous maneuvers being considered include one in which the *Gemini* would tip over on a hinge, placing it parallel to the *MOL* and permitting access through the sides of each craft. The *MOL* might also be designed with ports on the side to accommodate the neck of the *Gemini* for simple rendezvous maneuvers.

The Air Force has given notice that it deems the rendezvous mission essential, although DOD has not given a go-ahead.

Ferguson described the *MOL* as having two pressurized crew compartments and one unpressurized compartment at the base.

- **Simulator coming**—The School of Aerospace Medicine (SAM) at Brooks AFB here will have a laboratory version of the *Manned Orbiting Laboratory (MOL)* by this summer.

Maj. Gen. T. C. Bedwell, commander of the Aerospace Medical Division (AMD), said that as in the first model of the orbiting system, the simulator would carry supplies for 30 days' flight duration. Bedwell also indicated that the Air Force hoped to extend the mission time of the *MOL* to two or even three months.

The environmental chamber, which Bedwell said was ordered in anticipation of AMD's support role in the orbiting lab program, will closely approximate the estimated dimensions of the *MOL,* and AF officials said they hoped to get a *Gemini* mockup to complete the simulation.

Most *MOL* tasks, including extravehicular suit operation, could be tested with the new system. With the use of a depressurized airlock between the "can" and the *Gemini,* the physiological problem of getting out of the *Gemini* in space and moving around to the *MOL* can be studied.

- **Plastinauts may fly**—AF space medicine experts attending the annual lectures in aerospace medicine speculated on some of the possibilities of the orbiting laboratory for experimentation.

Lt. Col. Edwin Ballinger, radiation expert for the AMD, suggested that the Air Force "plastinaut," a plastic dummy whose tissue characteristics simulate man's, could be orbited in the early unmanned checkout of the *MOL* to get exact radiation data. The dummy could also be put out in space, he said, to get direct radiation information for extravehicular operation.

The Aerospace Medical Division will play a large part in *MOL* development, being responsible for life support and some experimentation. However, most officials seemed to feel that the orbiting laboratory will be used to experiment with mission-type operations rather than pure research in the space environment.

A delegation of AMD officers led by Col. Andres Karstens, chief of the Aerospace Medical Research Lab at Wright-Patterson AFB, will be assigned to Space Systems Division headquarters under Brig. Gen. Joseph C. Bleymaier.

- **Good research tool**—Dr. Billy Welch, chief of SAM's environmental systems branch, said the most significant thing about the new simulator is that it will have a double wall construc-

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tion, insuring that there is no inboard leakage.

The cabin will play a big part in determining the optimum atmosphere for *MOL*—whether it should be 100% oxygen at 5 psia or a two-gas system. Preliminary data indicate that the AF has pushed up the 100% oxygen "safety checkout" to 30 days, but AF medics feel that much more basic research must be done before the go-ahead can be given for possible two- or three-month missions.

SAM doctors are evaluating all the data from the recent 30 days' exposure and will reserve final judgment until this is done. Next tests probably will be a repeat of the 30-day experiment to reinforce their findings, and AF doctors indicated they wanted to make sure they had all the backups so they could avoid the kind of flap NASA encountered in the *Apollo* environment decision.

Later experimentation will be made on oxygen-nitrogen and oxygen-helium environments.

- **June delivery**—The new chamber will be delivered to SAM in June by the MRD Division of General Transportation Corp., Niles, Ill.

The chamber was built to specifications drawn up by SAM personnel. The three-module construction of the laboratory will include provisions for a cockpit, a work area and a rest area. The main 1,000-cu.-ft. cylinder is 8 ft. wide and 19 ft. long, and is attached to a 4-ft., 4,000-cu.-ft. air lock. The *Gemini* would be attached to the other end of the air lock—not the same arrangement as will be used in space, but permitting experimentation in the vacuum between egress from the *Gemini* and entrance into the *MOL*.

The chamber can house four men. Although conventional eating and bathing equipment will be installed initially, Welch pointed out that the chamber has built-in attachments so that the internal arrangement can be altered and other equipment may be tested in this ground laboratory.

Test subjects will be monitored by TV cameras and voice communication. The chamber has 2,000 electrical penetrations, and 120-150 gas or fluid penetrations, all double-valved to minimize inboard leakage, Welch said. It also has pressure-suit outlets for these experiments.

- **Gaseous environment**—Standard equipment outside the capsule will be used to maintain the cabin atmosphere. Lithium hydroxide will be used to scrub carbon dioxide except when regenerative systems are tested. Humidity will be maintained at 60-90%.

The annulus, or a space in the two-wall construction, will be kept at a lower pressure than the inside of the cabin to absolutely insure that no outside gases leak in. Welch said engineers are striving for zero leakage.

Track contaminants will be sensed by mass spectroscopy, gas chromatography and infrared spectroscopy. ■

NASA Establishing Solar Flare Prediction Network

NASA is setting up solar observation stations along the Deep Space Instrumentation Facility network, and a forward-scatter system across the northern portion of Canada in an effort to gain more data on how to predict solar flares.

All these stations will be in operation in the next few years and will measure: 1) type IV radio noise outbursts associated with solar flares; 2) continuous photographic coverage of the Sun in the hydrogen-alpha wavelength clearly showing plagues, spots and flares as they occur, and 3) forward scatter network to measure the flux and form of the flare as it reaches the Earth.

NASA official John M. Eggleston said that these data would be distributed to the scientific community as they are obtained. Eggleston said that although the *Apollo* mission will occur during the maximum point in the solar flare cycle of the Sun, there may be some hope that some times of the year are better than others for launching. He indicated that in one cycle—the period from the first of December to the middle of January and the period from mid-May to early July—no flare occurred. He added, however, that this could be just coincidence.

As the mission now stands, the *Apollo* astronaut will get the specified critical dose (200 RAD) on less than one mission in 1,000, except for the eyes. For this eventuality, the astronauts will be equipped with transparent visors, which can be brought down over their eyes during emergency periods. Eggleston said that in passenger miles, the chance of radiation illness is about three cases of sickness in a billion miles.

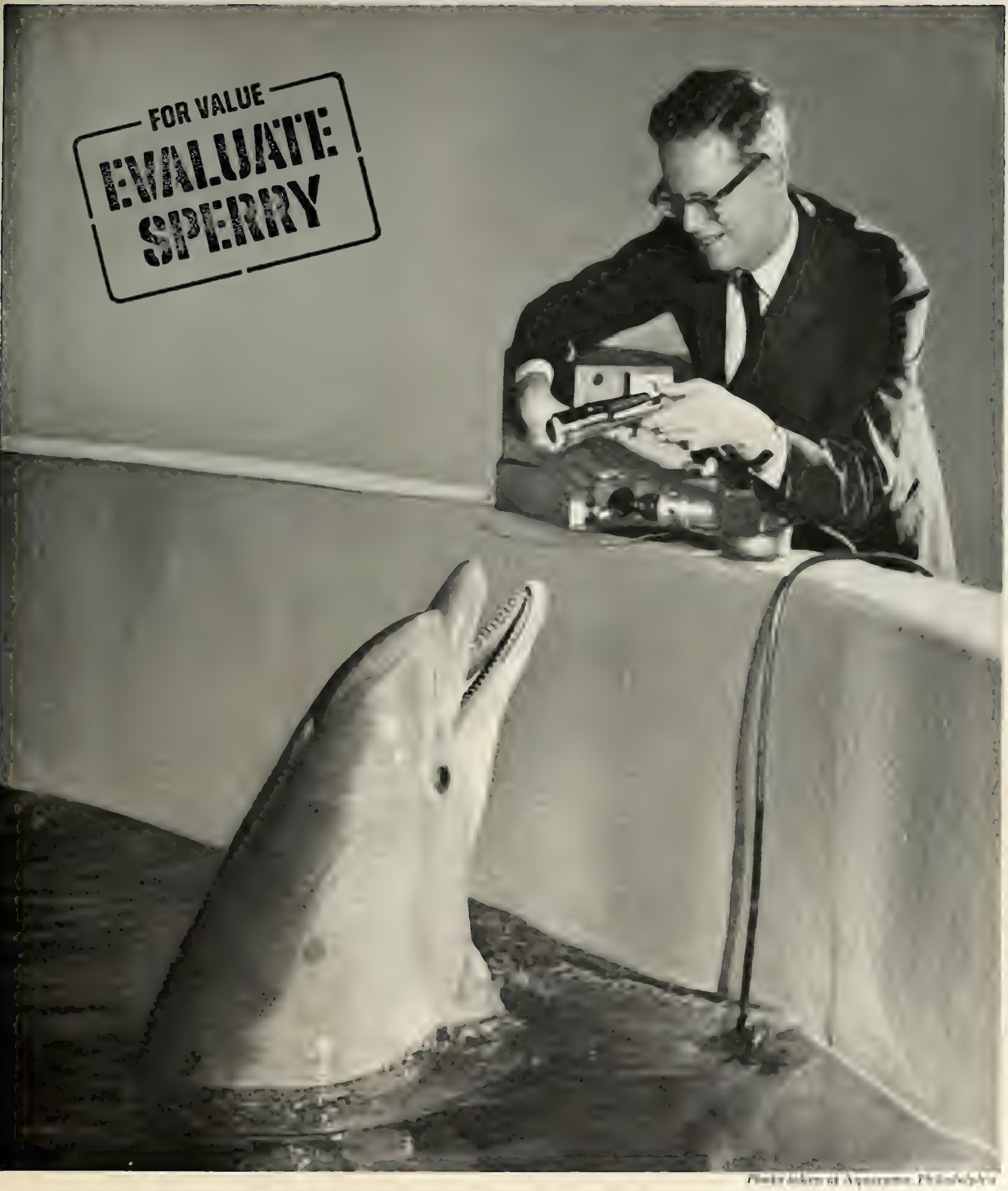

Photo taken at Aquarama, Philadelphia

Dolphin spoken here? The time may not be far away. Already at Sperry we have developed a tiny computer—the SCEPTRON™ Pattern Recognizer—which can memorize, distinguish between and react to different sights and sounds. In the foreseeable future such a device may be able to translate the language of, say, the dolphin (a particularly smart mammal) into human terms, and vice-versa—thereby establishing a crude intercommunication. What a world of understanding and knowledge might open up. □ The SCEPTRON—a "brain cell" of tiny optic fibers—is a product of Sperry research, which has also produced Loran-C, the rotation rate ring laser, the photoparametric diode, "heads up" windshield display for aircraft, fluid sphere and tube gyros and other technical advances. *General Offices: Great Neck, New York.*

SPERRY

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Big-Solid Saturn Hopes Discounted

Space agency official expresses doubts at AIAA meeting but industry advocates insist they have NASA encouragement

by Willard E. Wilks

PALO ALTO, CALIF.—A renewed all-out effort by big solids enthusiasts for a parellel program for *Saturn* boosters came out at the solid-propellant rocket conference of the American Institute of Aeronautics and Astronautics last week.

The campaign to convince NASA that it can save *Apollo* program money by using the 260-in. solid motor on *Saturn* vehicles was immediately reported headed for failure by a top NASA official who told MISSILES AND ROCKETS "We have seen presentations by the companies. They have spent a lot of money in big facilities and they are running scared. The probability is very low for a parallel program."

The spokesman disputed figures presented by industry sources that savings could be realized by using half-length 260-in. motors to boost *Saturn IB*.

"Big solids won't sell as a direct replacement. The only way would be in event a requirement develops for an appreciably larger payload, say 60,000 lbs. or more. Faced with a choice of making multiple *Saturn* launches or doing it with big solids, we might decide on the latter."

- **260-in. pitch**—Dr. Werner Kirchner, vice president and manager of Aerojet-General's solid rocket plant, Sacramento, Calif., told M/R at the conference that the 260-in. could be used at a saving on both *Saturn IB* and *Saturn V*.

"I'm asking for a parallel program with a limited number of firings in the next two years. A decision could be made on which to use, solids or liquids, in 1966. I think the program would be so conclusive at that time that we would use solids on the bottom stages, the full 260-in. clustered for *Saturn V*."

Kirchner recommended use of the half-length 260-in. motor on *Saturn IB* to enable placing the entire integrated *Apollo* assembly into Earth orbit for tests with a single launch. "With this, we can put 49,000 lbs. into orbit—optimized, up to 69,000 lbs.—against 32,000 lbs. for the current vehicle, which will only take elements of the *Apollo* assembly."

The NASA official, however, in addition to throwing cold water on the solids-for-*Saturn* push made a point of emphasizing that any report on the agency's big solid effort "should present a picture of a continuing, lean, hungry program—nothing radical."

- **Split in NASA?**—One industry source expressed some surprise at these comments and indicated that he had received NASA encouragement. "I think there is a big drive on to get application for the full-length 260-in.," he said, noting big-solid application studies encouraged by both NASA and the Dept. of Defense.

Other industry spokesmen reported NASA is providing a good deal of behind-the-scenes encouragement for big solids application. "The thing is," one said, "that those people in NASA who are enthusiastic about big solids have to keep their heads down or have a ton of bricks fall on them."

A proposal for a half-length 260-in. boosting an S-IVB stage was reported drawing significant NASA interest. This would provide a vehicle for development of equipment for the *Saturn* program, reportedly for about half the cost of using *Saturn IB*.

Industry spokesmen said big solids hope also was being strengthened by space agency and Dept. of Defense studies for direct application to vehicles. Overall evaluation studies of big liquids and solids are under way, considering schedule, reliability, cost, time to develop and man-rating. ■

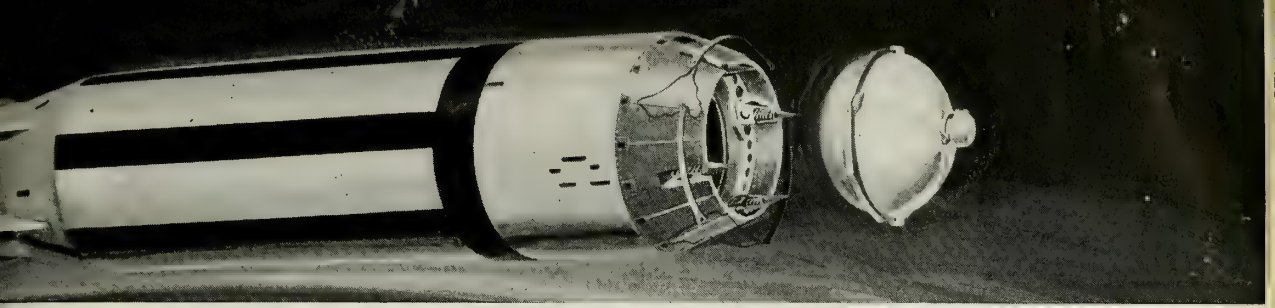
EMP Warnings at Electronics Meeting

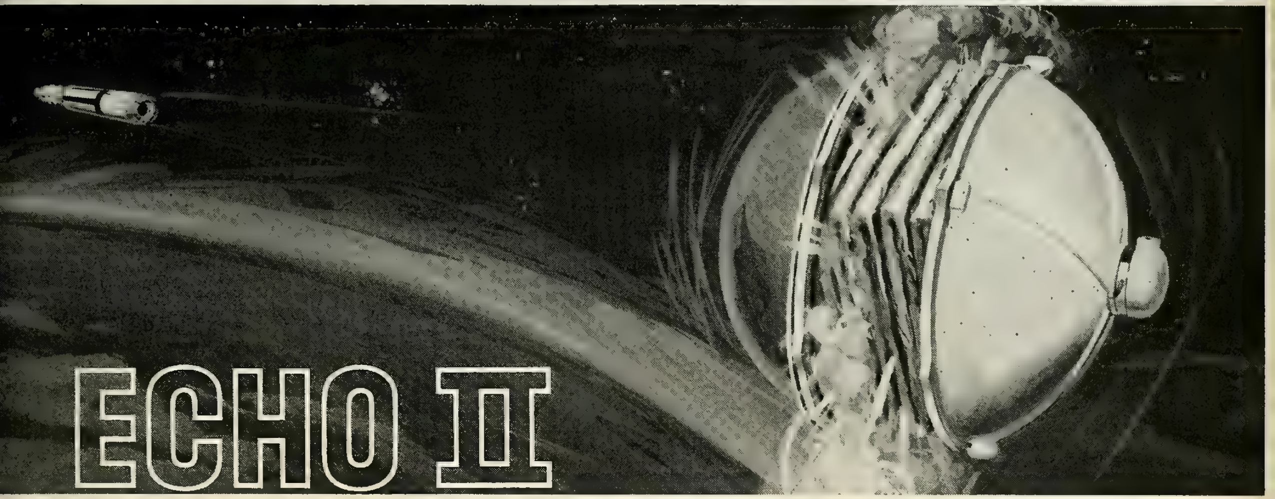
LOS ANGELES—Protection against nuclear electromagnetic pulse (EMP) can only be achieved on a total system basis, warned speakers at the 1964 National Winter Convention on Military Electronics here last week.

Engineers from Stanford Linear Acceleration Center and Joslyn Electronic Systems Division emphasized that sensitivity of semiconductor junctions requires a new approach to protection, using self-healing protectors such as gas-filled gaps. Even links as short as a missile umbilical cord can, they said, produce critical voltages in response to an EMP.

A paper from Picatinny Arsenal reported documented instances in which high-intensity RF fields had caused premature firing of weapons. The arsenal has developed a high-power transmitter system to simulate nuclear EMP.

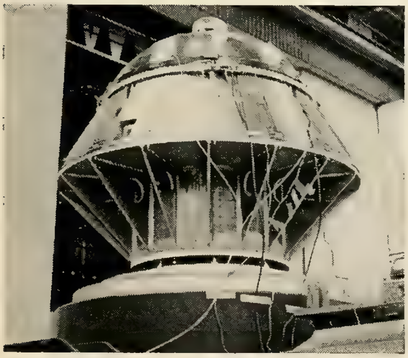
Other papers disclosed improvements in antisubmarine warfare. Recent advances in magnetometers and better information on geophysical background fields have greatly increased performance of magnetic detection techniques. Also described was an adaptive system for undersea target location by passive sonar, in which errors are minimized by weighting bearing information by an appropriate function of the signal-to-noise ratio.





another example of Grumman's aerospace capabilities...

Grumman's diverse capabilities in specialized areas of space technology were demonstrated on January 25 with the successful launching of Goddard Space Flight Center's Echo II passive communications satellite. Launched into a near polar orbit by a Thor Agena B vehicle, the Grumman-designed Echo II canister contained a 135-foot diameter balloon of Mylar plastic and aluminum foil laminate. After Agena B burnout, the vehicle coasted and was corrected for circular orbit. Pay load ejection and canister opening were delayed until pay load was over the island of Madagascar to get television pictures of the ejection, canister opening, and balloon inflation.



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- *Reduction of about 30 percent from specification maximum weight.*

Echo II canister; Orbiting Astronomical Observatory; Lunar Excursion Module—all are jobs that require special skills and capabilities. Skills and capabilities available at Grumman for the design, development and integration of advanced space systems. Grumman has the manpower, the research and test facilities and the management team to administer the most complex space programs.

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Mergers and Acquisitions

Electronics Fittings Corp., a wholly-owned subsidiary of Curtiss-Wright Corp., has purchased the electrical connector product lines of Precision Connectors, Inc., Jamaica, N.Y. The PCI line consists of sub-miniature, microminiature and printed board electrical connectors for missile, aircraft, computer and other applications. The purchase is aimed at expanding C-W product lines in the connector field. Electronic Fittings Corp. manufacturers CURTAC multi-wire connectors, RF connectors, thermal time delay and solid-state relays. . . . *Emtec, Inc., Elyria, Ohio, has acquired Components Engineering and Manufacturing Co., Inc., of Glendale, Calif. The new organization will be known as Emtec, Inc., CEM Div. CEM manufactures precision hardware and fasteners for the missile/space industry in 11 western states for both civilian and military use.* . . . The Grow Corp. has acquired Churchill Chemical Corp., Los Angeles, a supplier of specialized chemical compounds to the missile/space, aircraft, electronics, marine and construction industries. Churchill will be operated as a subsidiary of Grow Corp. . . . *International Telephone and Telegraph Corp. has acquired the assets and business of the Gilfillan Corp., Los Angeles, developers and producers of missile/space and aircraft electronics systems. The operation will continue as an ITT subsidiary under the name ITT Gilfillan, Inc.*

New Firms and Divisions

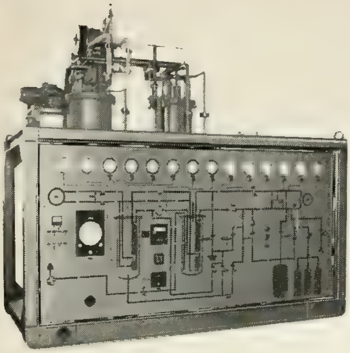
The WMA Andersen Co. has been formed to manufacture solid-state video and bandpass amplifiers in Pleasant Valley, Conn. The company also plans to place special emphasis on ultralinear vacuum tube amplifiers. . . . *Barry Controls, Watertown, Mass., has established a new, independent branch, Barry Research and Development, to undertake contract research in mechanical dynamics. The branch is equipped to provide industry with engineering analysis, design and data reduction services required for solution of mechanical vibration, shock, and acoustic noise problems. Typical projects range from theoretical analysis to the development and application of basic engineering principles for the solution of missile/space, marine or Earth-bound dynamics problems.*

International

Ampex Corp., Redwood City, Calif., and Tokyo-Shibaura Electric Co. (Toshiba) of Japan have agreed in principle to the formation of a joint venture manufacturing company—Toshiba Ampex, KK (Toamco)—to serve the Japanese market. The agreement is subject to approval of the boards of directors of both companies and the Japanese government, all expected within 60 days, according to Ampex president, William E. Roberts. By providing a manufacturing base for its products within Japan, Ampex believes, Toamco will afford more effective penetration of the Japanese market. Videotape television recorders and accessories, computer memory products and scientific instrumentation recorders are expected to be among Ampex products manufactured in Japan. . . . *U.S. Polymeric Chemicals, Inc., Santa Ana, Calif., developer and manufacturer of preimpregnated plastic materials for missile/space applications, has sold a 50% interest in its Dutch subsidiary, Polymeric, N.V., to Koninklijke Zout-Ketjen, of The Netherlands, in a cash transaction. Polymeric, N.V., was established in Utrecht, Holland, in 1958 to supply materials developed in the U.S. to Common Market and NATO countries. The company supplies materials used in the production of the Sidewinder and Hawk missiles and Lockheed F-104 interceptors.* . . . Vitro Engineering Co., New York, has been named by Union Carbide India, Ltd., a subsidiary of Union Carbide Corp. to furnish design, engineering, procurement and construction management services for a $17.5-million polyethylene plant addition near Bombay, India. In addition to polyethylene, the plant will produce other organic chemicals, including ethylene, propylene, acetylene, acetaldehyde, crotonaldehyde, buranol, 2-ethyl-3-propyl acrolein, 2-ethyl hexanol and dioctylpthalate. . . . *Lear Siegler, Inc., Santa Monica, Calif., has acquired 83% interest in the West German optics firm of C. A. Steinheil Soehne GmbH Optische Werke in Munich. The acquisition is part of a planned move on the part of Lear Siegler to expand its international markets. Steinheil's product line includes spectrographs, oscillograph cameras, binoculars and special lenses for many types of cameras.* . . . Astronautics, Inc., Washington, D.C., international technical representatives, has been selected to co-sponsor the first telemetry symposiums in Europe. The symposiums are designed to acquaint and familiarize European missile/space engineers with the latest scientific advances and technical developments in the state of telemetry and data processing art.

Industry Facilities

Sylvania Electronic Systems, a division of Sylvania Electric Products, Inc., has purchased an additional 9.6 acres of land at its Mountain View, Calif., plant. The company has also leased a 32,000-sq.-ft. facility nearby. The Sylvania division is engaged in research, development and production of electronic warfare, reconnaissance and security systems for various government agencies. . . . *The Aeronautical and Instrument Div. of Robertshaw Controls Co., Anaheim, Calif., has established four new regional sales offices. They are located in Los Angeles, Houston, Haddonfield, N.J., and Skokie, Ill. The division produces missile / space controls, communication equipment and instruments.* . . . Continental Device Corp., Hawthorne, Calif., manufacturer of semiconductor devices for space, military and industrial programs, has opened a 5,000-sq.-ft. pilot facility in Mooresville, N.C. The plant is the first step in the development of a major semiconductor manufacturing facility, expected to be in operation by the end of 1965.



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contracts

AIR FORCE

$30,500,000—**Boeing Co.**, Seattle, for continued fabrication, assembly and checkout of *Minuteman* ICBM systems.

$7,200,000—**General Telephone & Electronics Corp.**, Waltham, Mass., for continued production of equipment for a *Minuteman* test site at Vandenberg AFB, Calif.

$4,800,000—**North American Aviation, Inc., Autonetics Div.**, Anaheim, Calif., for continued production of guidance and control systems for *Minuteman* ICBMs.

$3,490,000—**Hughes Aircraft Co.**, Culver City, for work on a classified project (supplemental).

$2,500,000—**MIT, Instrumentation Laboratory**, Cambridge, Mass., for further research and development on improved inertial navigation techniques and instrumentation for ballistic missile guidance and control systems.

$1,680,000—**General Dynamics Corp., Astronautics Div.**, San Diego, Calif., for provision of service and supplies required to support the *Atlas* weapon system microfilm maintenance program.

$1,500,000—**Reynolds Metals Co.**, Richmond, Va., for production of electronic countermeasures.

$1,500,000—**Anaconda Aluminum Co.**, Louisville, Ky., for production of electronic countermeasures.

$1,381,000—**Litton Systems, Inc.**, Woodland Hills, Calif., for work on a classified program (supplemental).

$1,000,000—**FMC Corp.**, New York City, for production of UDMH propellant.

$1,000,000—**Aerojet-General Corp.**, Azusa, Calif., for follow-on research, design and production of electronic sensing equipment.

$200,000—**Martin Marietta Corp.**, Baltimore, for rocket propulsion system reliability and man rating analysis.

$174,365—**Thiokol Chemical Corp., Wasatch Div.**, Brigham City, Utah, for an exploratory development to demonstrate the performance of the TU-290 high-strength case rocket motor.

$106,950—**United Aircraft Corp., United Technology Center**, Sunnyvale, Calif., for a study of solid propellant rocket motors and their ignition systems when operating under a vacuum.

$59,690—**Fundamental Method Associates, Inc.**, Brooklyn, N.Y., for a research program covering dustwall meteoroid shielding.

ARMY

$6,261,600—**Blount Construction Co.**, Montgomery, Ala., for construction of a central instrumentation facility for handling electronic data gathered from rocket launchings in the Merritt Island launch area.

$5,200,000—**Robert E. McKee, Inc.**, El Paso, Tex., for construction of test facilities at White Sands Missile Range, N.M., for Lunar Excursion Module tests by NASA.

$5,500,000—**Elgin National Watch Co.**, Joliet, Ill., for assembly, test and shipment of metal devices for a special weapons system.

$2,200,000—**Intercontinental Manufacturing Co.**, Garland, Tex., for both first- and second-stage motor cases for the *Pershing* missile.

$1,999,821—**Martin Marietta Corp., Orlando Div.**, Fla., for production of modification kits for the *Pershing* missile system.

$1,900,000—**General Electric Co.**, Pittsfield, Mass., for modification kits for *Pershing* missiles.

$1,231,352—**Avco-Everett Research Laboratory**, Everett, Mass., for continued research in reentry physics and optical discrimination method.

$1,200,000—**General Dynamics Corp., Pomona Div.**, Calif, for continued research and development on the *Redeye* missile system.

$1,200,000—**Western Electric Co.**, Whippany, N.J., for work to support Project *Sleighride*, a reentry program.

NAVY

$15,700,000—**Defoe Shipbuilding Co**, Bay City, Mich., for construction of a guided missile destroyer for the Australian government.

$11,800,000—**General Electric Co.**, Pittsfield, Mass., for *Polaris A3* guidance components.

$5,300,000—**General Instrument Corp.**, Hicksville, N.Y., for electronic countermeasures.

$3,800,000—**Raytheon Co.**, Wayland, Mass., for missile radar set modification kits.

$3,600,000—**Northrop Corp., Nortronics Div.**, Norwood, Mass, for *Polaris* missile guidance system gyros.

$2,030,053—**General Electric Co.**, Pittsfield, Mass., for manufacture of modification kits and test instrumentation equipment for *Polaris* fire-control systems.

$1,800,000—**North American Aviation, Inc., Rocketdyne Div.**, Canoga Park, Calif., for further production of *Sparrow III* rocket motors.

$1,600,000—**Babcock Electronics Corp.**, Costa Mesa, Calif., for the production of test and checkout equipment to be used in conjunction with command control transmitting systems developed and manufactured by Babcock.

$75,000—**Climax Molybdenum Co. of Michigan**, Detroit, for a research and development study to evaluate high-strength tungsten-based alloys.

$73,845—**Clevite Corp., Mechanical Research Div.**, Cleveland, for a research and development program on ultra-high-temperature materials and composites for use in rocket nozzles and associated hardware.

$52,520—**Pressure Technology Corp. of America**, Woodbridge, N.J., for a study of the deformation characteristics of beryllium and tungsten under conditions of high hydrostatic pressure.

$49,338—**Aeroprojects, Inc.**, West Chester, Pa., for a study of thixotropic gelled propellant systems.

$45,725—**Minneapolis-Honeywell Co., Research Center**, Hopkins, Minn., for research on mechanical and micro-mechanical behavior of boron.

$39,381—**Flight Sciences Laboratory, Inc.**, Buffalo, N.Y., for research and development toward the optimum of hypersonic guided missile configuration.

NASA

$1,400,000—**Blaw-Knox Co.**, Pittsburgh, for design and construction of three 85-ft.-dia. parabolic antennas.

$188,200—**Bell Aerosystems Co.**, Buffalo, N.Y., for gas generator and turbine parts for fluorine rocket motors.

$146,000—**Budd Co., Electronics Div.**, McLean, Va., for ground-support cooling units to be mounted on the umbilical tower of the *Saturn IB* and *V* space vehicles.

INDUSTRY

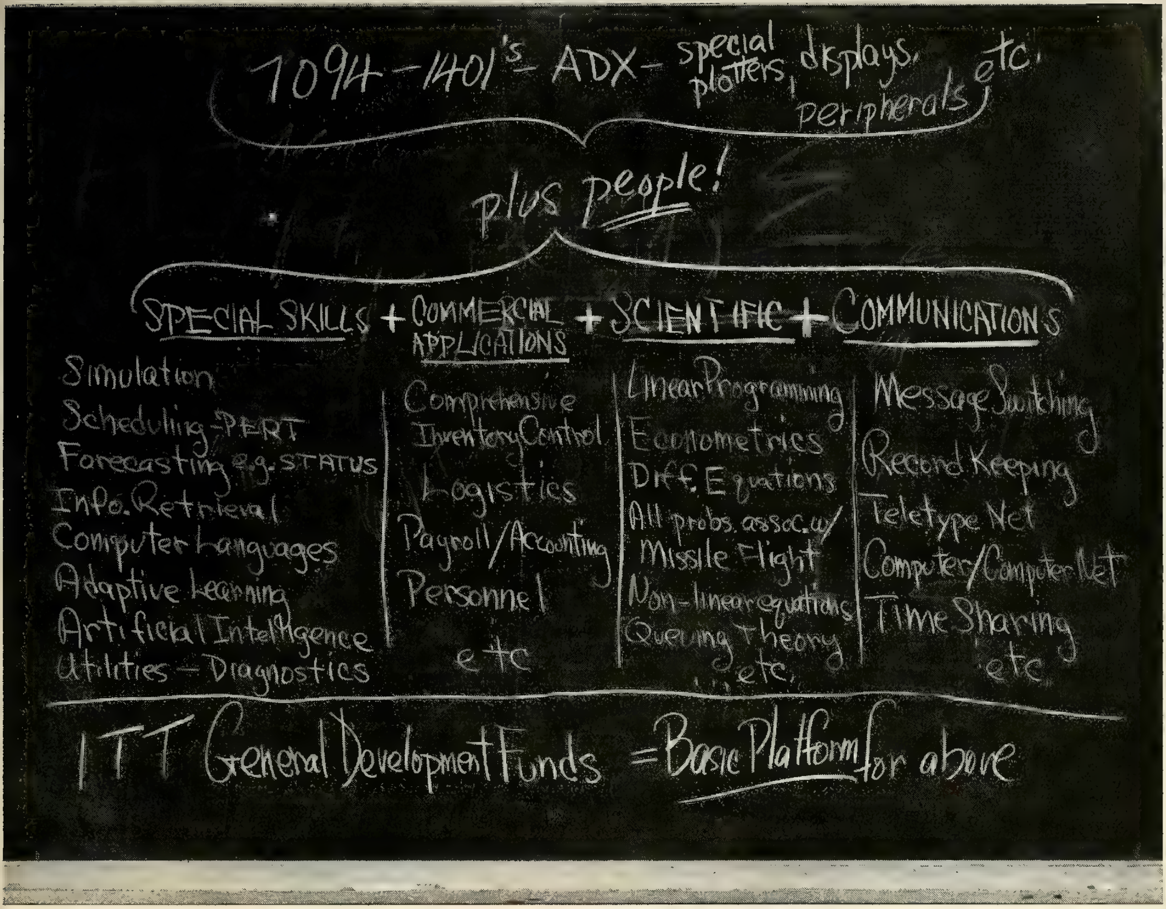
$14,800,000—**Martin Co., Orlando Div.**, Fla., from **Bell Telephone Labs**, for further development of the *Sprint* A-ICBM.

$4,000,000—**Marquardt Corp.**, Ogden, Utah, from **Aerojet-General**, for production of additional nozzles for the *Polaris* missile.

$2,200,000—**Ling-Temco-Vought, Inc.**, Dallas, from **Stanford University**, for super power pulse modulators to be used in atomic particle accelerators.

$2,000,000—**Thompson Ramo Wooldridge, Inc., Electro-Mechanical Div.**, Cleveland, from **Aerojet-General**, for rocket nozzles for the 260-in. solid propellant motor.

$1,000,000—**Bendix Corp., Pacific Div.**, North Hollywood, Calif., from **Boeing Co.**, for redesign of components for the transporter-erector-emplacement system for the advanced *Minuteman* missile, including the construction of a 95-ft. deep simulated launch silo for test purposes.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ITT **DATA AND INFORMATION SYSTEMS DIVISION**

missiles and rockets

DOD Military System

A Report on the DDR&E

DDR&E, the Directorate of Defense Research and Engineering, is one of the most important offices in the Department of Defense. It has a complement of 145 men, supervising some 30,000 others and directly affecting over 125,000 industry personnel. DDR&E annually contracts for $7 billion dollars in space and military systems research, development, test and engineering services from its suppliers.

The March 30 issue of MISSILES AND ROCKETS will present an in-depth report on DDR&E covering:

DDR&E Operation ▪ Relationships with Industry and the Services ▪ Current & Advanced Programs ▪ In-House R&D Capabilities ▪ Future Expenditures ▪ Key Personnel

Issue Date: March 30, 1964

ssue, March 30, 1964

The DOD Military Systems

Issue will be **must** reading for over 45,000 program and project managers, engineers, and scientists in industry and the military. Advertise in this issue to gain maximum exposure for your products, capabilities, or services.

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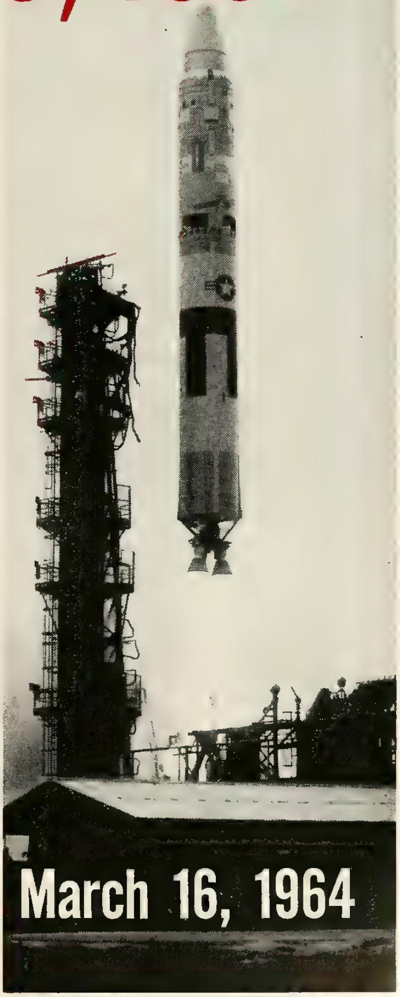
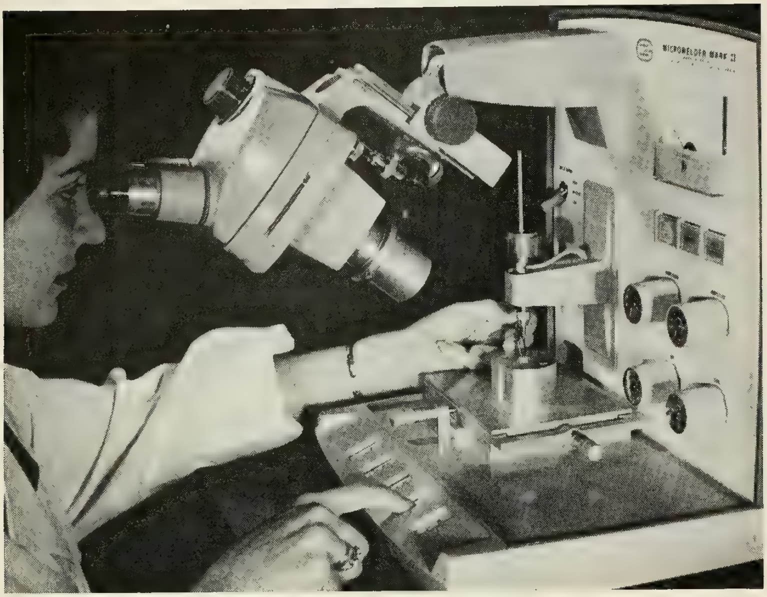


Advertising Closes: March 16, 1964

New Product of the Week: Microwelder



The Microwelder Mark II, a precision welding machine for microelectronic applications, has been developed by Aerojet-General Corp.

The resistance welder operates on 120-v, 60-cps, single phase. It features a single tip containing both electrodes, which allows welding of materials as small as 0.0005 in. to positions on 0.003-in. centers. Weights can be placed on the tip to provide absolute force control from 10 to 1,600 grams.

The device offers synchronous timing and three power ranges. Weld energy is adjustable by dial.

Circle No. 151 on Subscriber Service Card

Laboratory Amplifier

Hewlett-Packard Co. has available a solid-state laboratory amplifier with a response of ±1 db from 1 kc to 150 mc.

The Model 461A has a gain of 20 or 40 db, which may be set on the front panel. Output is up to 0.5v RMS into 50 ohms; equivalent wideband input noise level is under 40 μv with 40-db gain. Imput impedance is 50 ohms.

Circle No. 152 on Subscriber Service Card

Calibration Source

Horex Electronics, Inc., is marketing a high-accuracy ac voltage calibration source for checkout of RMS indicating voltmeters. Operation has been reduced to dialing of the desired RMS voltage.

The device is said to check the usual 6-range voltmeter in seconds with an accuracy of 0.1% of the reading. It has a 4-digit display with automatic decimal point locator. A momentary output switch protects the load in case of set-up error.

Circle No. 153 on Subscriber Service Card

Spectrum Analyzer

Spectran Electronics Corp. has developed the Model 100-50MS multiple-filter spectrum analyzer.

The device simultaneously analyzes any 5-kc frequency band from 100 cps to 25 kc. It uses 100 magnetostrictive filters with constant bandwidths of 50 cps spaced 50 cps apart. Output of each filter is amplified and goes to a separate stylus of the recorder. Output of the system, giving a plot of frequency vs. time and amplitude, is determined by the density of the trace on the paper.

Other bandwidths from 3 to 100 cps are available on request.

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Miami, Florida 33132
AP-63001

Circle No. 10 on Subscriber Service Card

Speed Control Kit

The Engineers Motomatic Speed Control Kit, for experimental purposes, is being marketed by Electro-Craft Corp.

The unit, featuring an adjustable speed control range of 1,000:1, can be used to set the speed of a unique dc motor, capable of handling 12 in.-oz. torque, by manual command or heat or light input. The motor will maintain a constant speed set anywhere between 5 and 5,000 rpm, regardless of changes in line voltage or load conditions.

The unit includes a single transistor amplifier and a four-transistor wide range circuit.

Circle No. 155 on Subscriber Service Card

Transistor Chopper Driver

Solid State Electronics Co., is marketing the Model TCD-101 transistor chopper driver, designed to provide suitable square-wave voltages for transistorized choppers and synchronous demodulators.

Four transformer-isolated outputs are available for applications requiring halfwave or fullwave modulation and demodulation. Specifications include a nominal output frequency of 2 to 10 kc; operating temperature range of —55° to 100°C; frequency conversion sensitivity of 1,000 cps per volt; and frequency response of dc to one-half of output frequency.

Circle No. 156 on Subscriber Service Card

new literature

TAPE MATERIALS SELECTOR —A rocket motor ablative tape materials selector file containing specifications for physical properties of 31 pre-impregnated reinforced plastic tapes is available from U.S. Polymeric Chemicals, Inc. The file, arranged in tabular form, lists ten key physical properties, specification approval, vehicle on which used and prime contractor for each tape.

Circle No. 157 on Subscriber Service Card

ELASTOMERIC MATERIALS BOOKLET—Vernay Laboratories, Inc., has available an illustrated booklet describing components and engineering devices based on elastomeric materials. The publication also covers research and development facilities used to advance the techniques of rubber manufacturing.

Circle No. 158 on Subscriber Service Card

TIN-LEAD RATIO CHART—Alpha Metals, Inc., has available a simplified tin-lead ratio chart to assist in solder selection. The chart is reprinted from a forthcoming book, "Solder & Soldering," by H.H. Manko. In addition to standard designations, the chart graphically incorporates the recommended alloy temperature during wetting.

Circle No. 159 on Subscriber Service Card

"O" RING REFERENCE CHART —Schulz Rubber Products is offering an "O" ring reference chart to aid in selection of the proper ring for a specific job. The characteristics of 460 different "O" rings have been broken down according to size, basic volume, common military series, rubber specifications, temperature range and service characteristics, and military specifications for fuels, hydraulic fluids, oils and greases. The chart also shows how to calculate standard and non-standard "O" ring installations.

Circle No. 160 on Subscriber Service Card

SILICONE MATERIALS REVIEW —Dow Corning is publishing a 12-page, illustrated review of silicone and silicone materials and materials systems. The bimonthly Materials News abstracts newest product and applications information about silicones and gives a variety of editorial references.

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Opportunities In . . .

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These positions result from the constant growth of our programs and possess excellent potential for personal advancement.

AERONAUTICS

Projects have both atmospheric and space applications and work includes preliminary design for configurations, drag estimation, stability and control parameter estimation, validation and detail of design by wind tunnel testing, and participation in trajectory studies to assure capability for the mission. Capability for structural analysis (vibration and flutter) is also needed. MS Degree level of competence is desired.

GUIDANCE AND CONTROL

Projects have both atmospheric and space applications and include analysis in both linear and non-linear systems. Some knowledge of the mathematics of optimum controls is desirable as is familiarity with the use of analog and digital computers in solving guidance and control problems. MS level of capability is desired.

OPERATIONS ANALYSIS

To perform operations analysis of complex military and space systems including trade-off studies on sub-system requirements and costs, leading to assessment of the technical and cost effectiveness of the total system. Knowledge of probability theory and its uses as well as use of digital and analog computers is required. MS level of competence desired.

SYSTEM TEST & INSTRUMENTATION

To conduct tests (including field tests) with special emphasis on telemetry systems. Familiarity with range of techniques and equipments for sounding rockets and probes in a developmental program is required.

PROPULSION

Assignments will include preliminary design of small, high performance solid propulsion systems. Problems include grain, case and nozzle design, specifications writing, and technical participation in developmental subcontracts. Knowledge of the use of analog and/or digital computers is essential as is knowledge of the present state-of-the-art. MS level preferred.

For details, write in strictest confidence to:

John A. Haverfield, Manager—Professional Placement

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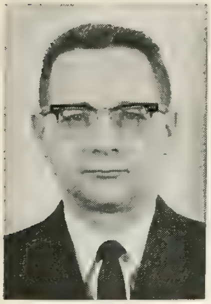
names in the news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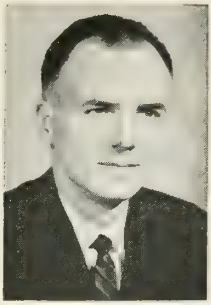
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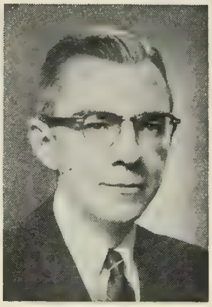

BENNETT

UNDERHILL

William C. Pembleton: Appointed administrative manager, applications engineering for Defense Electronics, Inc., Rockville, Md.

Robert Ledgerwood: Named manager of market planning for B. F. Goodrich Aerospace and Defense Products, Akron, Ohio.

Emmett N. Brownell: Appointed advertising manager for the Microwave Tube Group of Varian Associates, Palo Alto, Calif.

John Sodolski: Named staff manager of the Electronic Industries Assn. Systems Requirements Committee, Washington, D.C.

Harold Wolpman: Appointed vice president and general manager of Alloy Steel Products Co., Linden, N.J.

William F. Bennett: Elected president of General Telephone & Electronics International Inc., New York City.

Ned S. Underhill: Elected vice president-manufacturing of The Hallicrafters Co., Chicago.

John H. Striebel, Jr.: Appointed marketing manager for Electrol Incorporated, Kingston, N.Y.

Robert Hodges: Appointed general manager of Spectrolab, a division of Textron Electronics, Inc., Los Angeles.

Martin L. Touger: Appointed manager-design engineering at Radio Corp. of America's Communications Systems Div., Tucson, Ariz.

E. J. Brandt: Appointed manufacturing manager of Hopkins Engineering Co., San Fernando, Calif.

Jack Borsellino: Promoted to marketing manager for government and rocket operations at Thiokol Chemical Corp.'s Chemical Operations, Trenton, N.J.

Stanley B. O'Kane: Appointed treasurer of the Leach Corp., San Marino, Calif.

William S. Dickey: Appointed manager of the Tucson Research Laboratory of Textron's Bell Aerosystems Co.

Richard W. Sanford: Named director of engineering for the Middletown, Ohio, division of Aeronca Manufacturing Corp.

S. M. Treman: Appointed manager of engineering for the Defense and Industrial Div. of the Otis Elevator Co., Brooklyn.

John R. Hereford: Joined D. B. Milliken Co., Arcadia, Calif., as a research and development engineer specializing in advanced photo-instrumentation equipment.

Taylor C. Fletcher: Named director of research for the Special Projects Div. of Beckman Instruments, Inc., Fullerton, Calif.

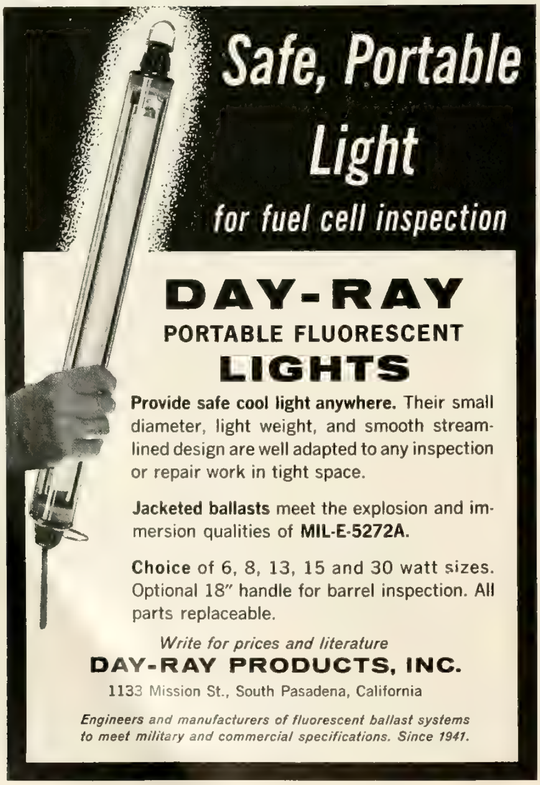
Arthur E. Wallach: Named manager of operations and government contracts for B. F. Goodrich Aerospace and Defense Products, Akron, Ohio.

Worthington W. Eckard: Named Washington, D.C. representative for the Marquardt Corp.

Robert H. Buescher: Appointed general manager for the Electronic Systems Div. of Fairchild Stratos Corp., Bay Shore, N.Y.

Dr. George R. White: Joined the staff of Electro-Optical Systems, Inc. as manager of the quantum physics division, Pasadena Calif.

John B. Cowan: Appointed vice president of marketing for the Space General Corp., El Monte, Calif.



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when and where

FEBRUARY

Golden Gate Metals Conference, American Society for Metals, Fairmont Hotel, San Francisco, Feb. 13-15.

American Institute of Mining, Metallurgical and Petroleum Engineers Annual Meeting, Statler-Hilton and Astor Hotels, New York City, Feb. 16-20.

ASCE Transportation Engineering Conference, Netherlands Hilton Hotel, Cincinnati, Feb. 17-21.

International Solid State Circuits Conference, sponsored by IEEE and the University of Pennsylvania, Sheraton Hotel and University of Pennsylvania, Philadelphia, Feb. 19-21.

Pricing and Negotiating Prime and Sub-Contracts in the Defense and Aerospace Industries Seminar, sponsored by the Contract Management Institute, Savoy-Hilton Hotel, New York City, Feb. 24-28.

Ninth Scintillation and Semiconducter Counter Symposium, sponsored by IEEE, AEC and NBS, Shoreham Hotel, Washington, D.C., Feb. 26-28.

MARCH

ASME Gas Turbine Conference and Products Show, Shamrock Hilton Hotel, Houston, Mar. 1-5.

Atmospheric Problems of Aerospace Vehicles, sponsored by FAA and AMS, National Aviation Facilities Experimental, Atlantic City, N.J., Mar. 2-5.

15th Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Penn-Sheraton Hotel, Pittsburgh, Mar. 2-6.

Fifth Symposium on Thermal Radiation of Solids, Sheraton-Palace Hotel, San Francisco, Mar. 4-6.

Southeastern Conference on Theoretical and Applied Mechanics, Georgia Institute of Technology, Atlanta, Mar. 5-6.

AIAA Aerodynamic Testing Conference, Marriott Twin Bridges Motor Hotel, Washington, D.C., Mar. 9-10.

National Association of Corrosion Engineers Annual Conference and Corrosion Show, Sherman Hotel, Chicago, Mar. 9-13.

Air Force Cambridge Research Laboratories Exploding Wire Conference, Kenmore Hotel, Boston, Mar. 10-12.

Society for Nondestructive Testing Spring National Convention, Chapman-Park Hotel, Los Angeles, Mar. 16-19.

NBS Symposium on Statistical Association Methods for Mechanized Documentation, National Bureau of Standards, Washington, D.C., Mar. 17-19.

Third Hypervelocity Techniques Symposium, Denver, Colo., Mar. 17-18.

IEEE International Convention, Hilton Hotel and Coliseum, New York City, Mar. 23-26.

American Meteorological Society National Conference on Physics and Dynamics of Clouds, University of Chicago, Chicago, Mar. 24-26.

Southwest Research Institute Aerospace Bearing Conference, San Antonio, Mar. 25-27.

Technical Symposium, sponsored by Polytechnic Institute of Brooklyn, IRE, AIEE, Army, Navy and Air Force, New York City, Mar. 31-Apr. 2.

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A $150-Million Failure

LET'S FACE THE HARD FACTS. *Ranger VI* was a 100% failure. We are fed up with hearing about what a successful launch it was, how well the guidance worked, how it impacted at just the right spot on the lunar surface.

The mission of *Ranger VI* was not to impact the Moon. It was to relay television pictures of the Moon's surface to Earth for use in the *Apollo* project. It failed completely, utterly, abysmally.

It was a $28-million failure. The program to date is at least a $150-million failure. *Ranger I* failed. *Ranger II* failed. *Ranger III* failed. *Ranger IV* failed. *Ranger V* failed. And *Ranger VI* failed.

With NASA budget hearings under way, the latest disaster marred a badly-needed New Year series of NASA successes, following closely the laudable *Saturn* and *Echo* launches.

The failure was the third in succession for the spacecraft itself. It raises again the question of the competence of Jet Propulsion Laboratory and its Cal Tech parent in management of the program.

We carry in the Letters column of this issue a defense of the *Ranger* program which suggests that JPL, as system manager, cannot be held responsible for failure of parts of the system. We reject such a philosophy entirely. With the authority goes the responsibility. JPL is program manager and the string of failures must be laid at that door.

Our correspondent also takes us to task for reporting that Northrop was to be brought into the program as spacecraft systems manager due to dissatisfaction with the quality control and reliability record of JPL. The NASA hearings of last spring, and the Kelley report, make it clear that is just why Northrop was due to take over, an event forestalled by cancellation of the latter part of the *Ranger* series due to the delays in the program.

The record on *Ranger* of JPL, a non-profit organization operating under the overlordship of Cal Tech, is a disgrace. It cannot be excused by other JPL successes. We suggest that in private industry the individuals responsible for such a record would have their heads on a chopping block.

Perhaps that is one of the difficulties. In NASA hearings last spring on *Ranger*, Rep. Joseph Karth (D-Minn.) asked Edgar Cortright, deputy director of NASA's Office of Space Sciences:

"Has anyone been dismissed for anything?"

Mr. Cortright replied: "Not to my knowledge. There has been some shifting around of personnel."

The failure which blinded the TV eyes of *Ranger* as it smashed uselessly into the Sea of Tranquility was not a complete surprise. Just such a failure was of specific concern as early as last March 11 when *Ranger* was reviewed by the House Space Sciences Subcommittee.

Discussing plans to improve the spacecraft, Mr. Cortright told the committee then: "To provide redundancy, the television equipment, where we have six cameras on the impacting TV systems, are being separated completely, three and three, so that one system can fail and the other will work."

Now, following the *Ranger VI* failure, it comes out that the two systems are both dependent on a single command system. We are aware of the weight problems involved in providing separate command systems but, at best, Mr. Cortright was being less than frank in his explanation.

It is somewhat akin to saying that you are building a second road to get from Point A to Point B in the event the first road is flooded, and neglecting to explain that the roads cross at one point—in a creek.

LET'S TAKE A LOOK at the relationship between NASA and JPL and Cal Tech. The Pasadena, Calif., laboratory is the only NASA facility where NASA owns all the land, owns all the equipment, pays all the bills and allows a non-profit corporation to run the facility.

For the privilege of operating JPL, the California Institute of Technology is being paid an estimated fee for Fiscal 1964 of $1.2 million. None of this million-dollar fee goes to JPL director Dr. William Pickering or anyone else working at the Laboratory. It goes to Cal Tech for managing JPL while JPL manages programs. And what is NASA getting for this sum?

This is what Mr. Albert Siepert, director of NASA's Office of Administration, had to say about that: "The principal thing that Cal Tech feels they give us for this is the association of Cal Tech in this effort as an eminent academic institution."

That may be exactly the heart of the problem. An academic environment is neither comparable nor conducive to the kind of hard-driving industrial atmosphere required to make complex space hardware function in a highly reliable manner.

A price of $1.2 million for leisurely university atmosphere and little else is exorbitant.

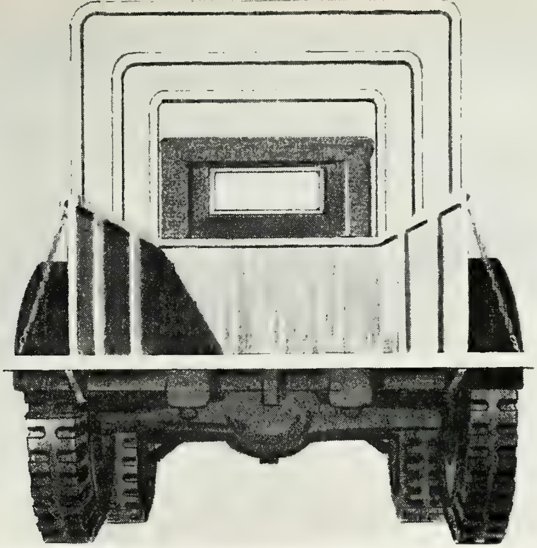
It is particularly unwholesome when it is realized that this entire setup operates so that JPL can function free of civil service.

Marshall Space Flight Center and Goddard Space Flight Center have achieved excellent launch records. They have accomplished this on government salary scales which are less than non-profit JPL pays.

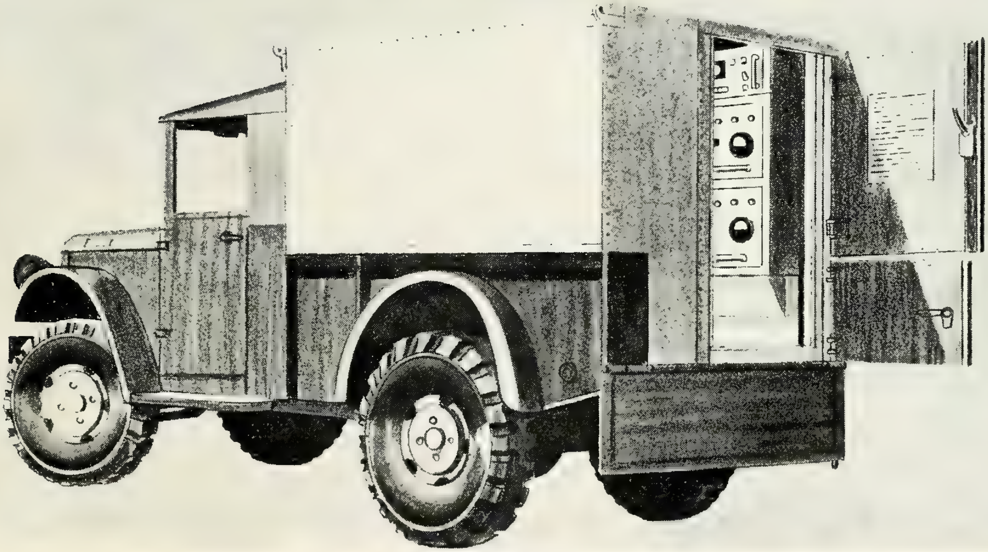
Last spring, Mr. Cortright had this to say to Congress about JPL: "It is now evident they would benefit materially from help of the type they will get from Northrop . . . the quality control was spotty. The uniformity of standards from technical division to technical division varied considerably. The monitoring of their subcontractors varied considerably from division to division . . ."

With this in mind, with the distasteful record of *Ranger* failures in mind, with the non-civil service JPL salary scales in mind, with the $1.2-million fee to Cal Tech in mind, we think Congress should reopen the whole question of the JPL-Cal Tech relationship.

William J. Coughlin



Could you put a 50 kw transmitter in this space?



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Series ST transmitters have made it possible to apply high power communications techniques (up to 150 kw) in many areas where tube-type transmitters are impractical. Using Westinghouse-developed all-solid-state circuitry, such restricted environments as ships, submarines, aircraft and tactical vehicles can now support advanced high power communications systems.

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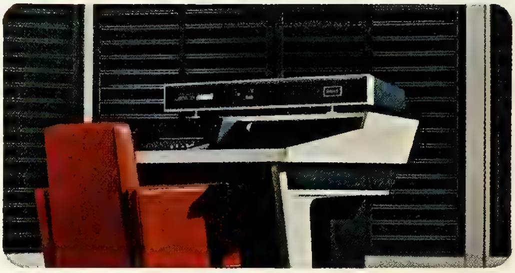
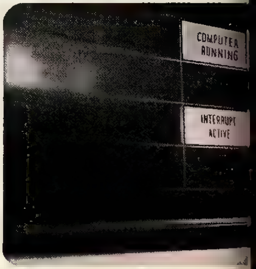
3400





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Detailed information is now available on the **CONTROL DATA 3400** through the Control Data Corporation representative who calls on your organization.

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FEBRUARY 17, 1964

nissiles and rockets

HE WEEKLY OF SPACE SYSTEMS ENGINEERING

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First Step Taken in Definition Of MOL

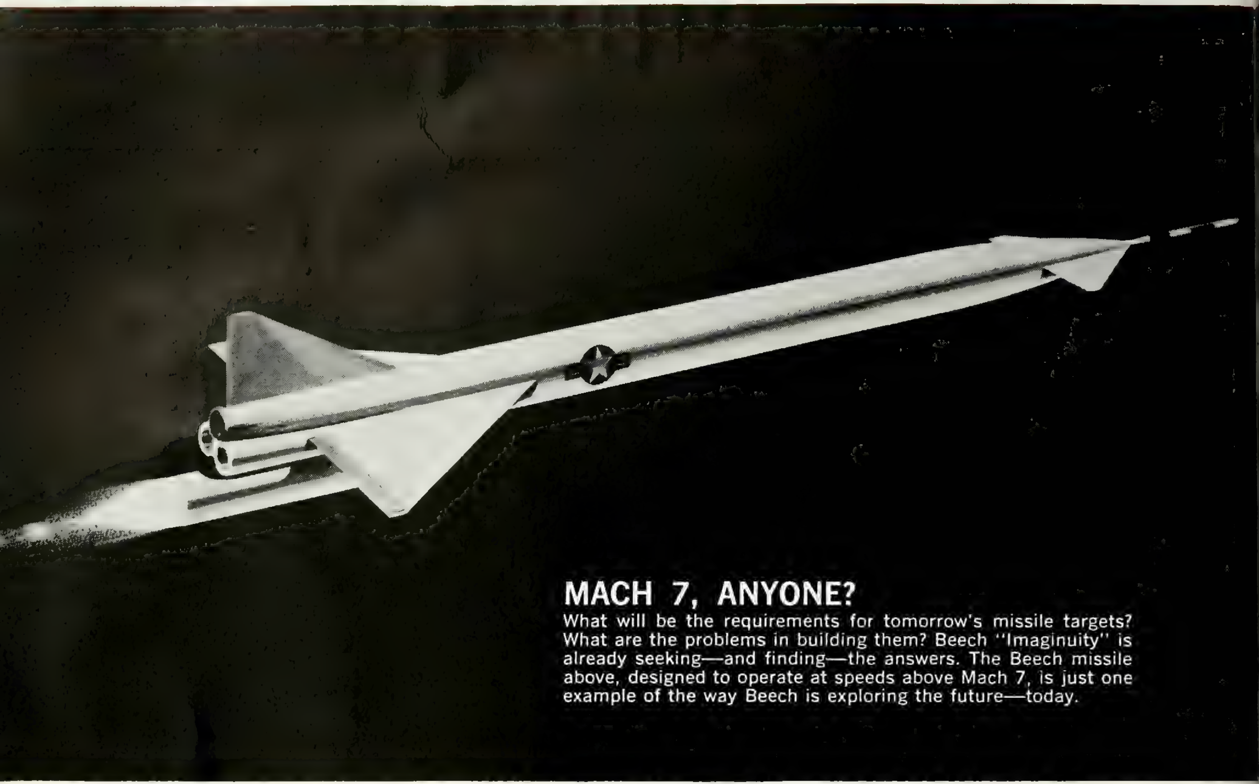
New Threat to MMRBM Funding

Boston Center Plan To Be Probed

EDITAR Tracking Highly Accurate

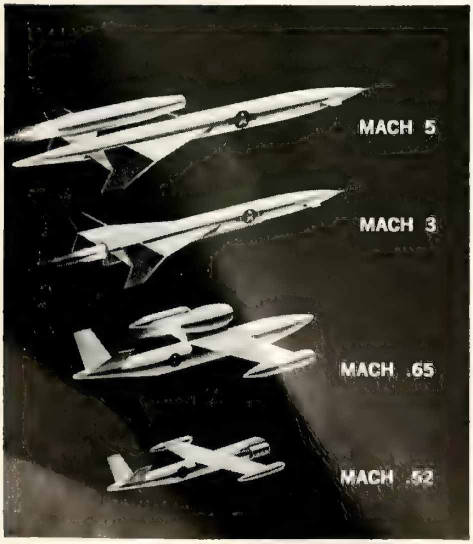
Korad's 500-megawatt Pulsed Laser

Beech "Imaginuity" in Missile Systems



MACH 7, ANYONE?
What will be the requirements for tomorrow's missile targets? What are the problems in building them? Beech "Imaginuity" is already seeking—and finding—the answers. The Beech missile above, designed to operate at speeds above Mach 7, is just one example of the way Beech is exploring the future—today.

If you want to pass this Beech missile target, you'd better be doing Mach 8—or better!



Now from America's first family of missile targets, comes the newest example of Beech "Imaginuity":

Today's modern air defense systems are only as effective as the shooting skills of the men who aim and fire them. To provide the realistic training needed to keep America's air defense units combat ready, Beech is building and has designed an entire family of missile systems to accomplish a variety of missions. They range in speed from Mach .52 to over Mach 7, with altitude capabilities from sea level to over 100,000 feet.

Two Beech missile target systems, the propeller-driven U. S. Army MQM-39A "Cardinal" and the rocket-powered U. S. Navy AQM-37A (KD2B-1), are already being produced in quantity. The AQM-37A is capable now of speeds above Mach 3. It gives today's most advanced weapon systems a realistic challenge to their capabilities.

This kind of successful experience in developing and building entire missile systems has given Beech a head start on the future. We are ready now to put Beech "Imaginuity" in design, development, fabrication and testing to work on the even more advanced missile systems that will be required for tomorrow's training and air defense requirements. May we tell you more?

▷

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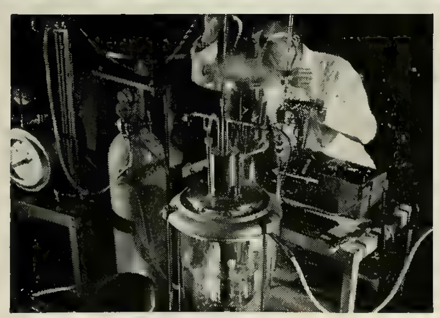

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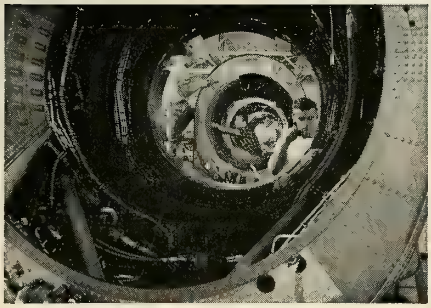
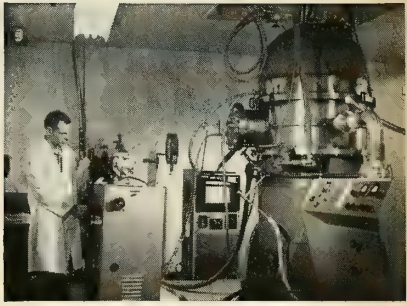
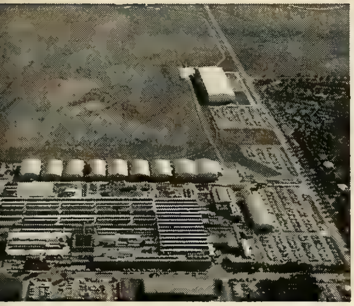


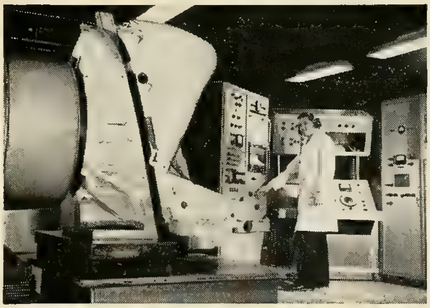
Manufacturing...



Space Simulation...



Facilities...



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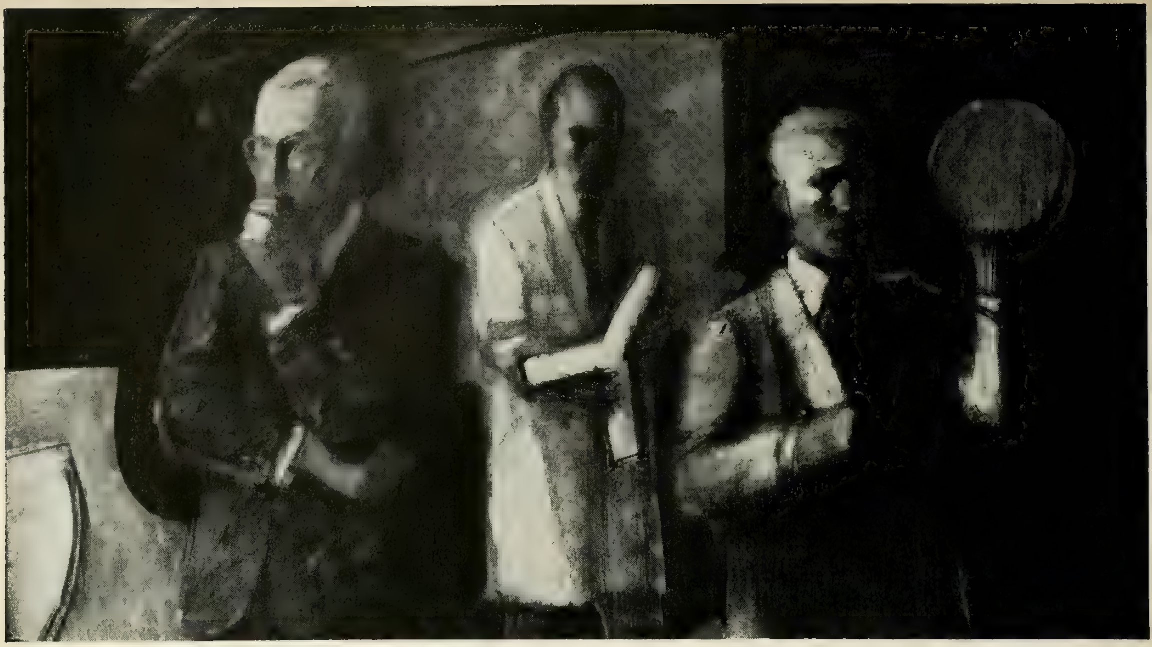

Helping unlock the nuclear future

Potentialities of the peaceful atom cannot be realized without the aid of dedicated scientists and engineers. Today at Atomics International, such men are needed to help blaze new trails in research and development. Present AI projects range from SNAP nuclear space power systems to advanced central station power reactors.

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AI offers exciting opportunities in:

HEAT TRANSFER AND FLUID MECHANICS Theoretical and experimental heat transfer research, fluid mechanics, and hydraulics research, including hydro-dynamic performance of fuel elements and investigation of convective and boiling heat transfer characteristics of reactor coolants.

REACTOR CORE ANALYSIS Core analysis of reactors including both core statics (criticality, reactivity, coefficients, control statics) and stability analysis (core transients, amplitude response, interpretation of oscillator and noise measurements).

SYSTEMS ANALYSIS Analysis and simulation of complete nuclear power plants to develop reliable, unattended, completely automatic control and instrumentation systems including reactor kinetics, dynamics, hazards and reliability analysis.

REACTOR SHIELDING Experimental and analytical shielding techniques and materials development for both central station and compact power reactors.

STRESS ANALYSIS Experience in either thermal stress or dynamic stress resulting from shock and vibration loads in aircraft structures. Responsibilities will entail design support for compact nuclear power plants for space applications including review of all designs with respect to stresses resulting from thermo gradients and transients, static loadings, and vibrational and shock loadings.

FUEL ELEMENT DEVELOPMENT Studies of the behavior of nuclear fuel materials and elements under simulated reactor operating conditions. These studies include both in-pile and out-of-pile tests, fuel evaluations, and projection to predict actual operational behavior. Also, development of processing and fabrication techniques for fuel elements, including melting, rolling, powder metallurgy processes, joining, etc. Results from these studies will contribute toward the improved design of fuel elements for the reactors under development.

Contact: Mr. H.B. Newton, Personnel Office, Atomics International, 8900 DeSoto Avenue, Canoga Park, Calif.

All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

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missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING Volume 14, Number 7 February 17, 1964

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THE COVER

Described as "the highest powered laser commercially available," this Korad Corp. unit requires no amplifier to develop peak power of 500 megawatts (M/R, Feb. 10, p. 23). Korad foresees its application in range finding on space vehicles, and says laser is accurate to within one foot at 300 miles under optimum conditions.

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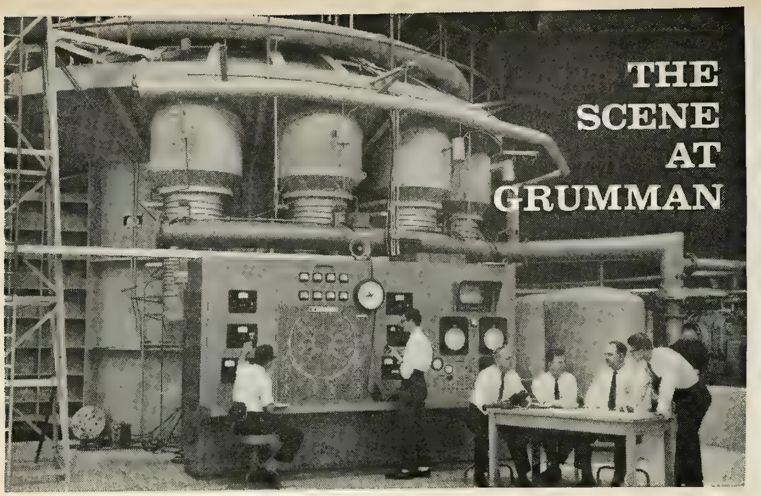

...Thermal Evaluation

Thermal evaluation of space vehicles and satellites is made in Grumman's large space vacuum chamber. This is part of a test development program which also includes spectrophotometer experiments, absorptivity-emissivity evaluations and structural temperature gradient determinations with sections of its vehicles, using a small vacuum chamber with solar simulator.

Shown above at the console Nick Mantzouranis, Test Engineer (joined Grumman March '63) and Bernard Chmiel, Technician (joined Grumman '60); and at the table Joe Szymanski, Assistant Foreman, Environmental Test Lab (joined Grumman '51), Charles Walthers, Thermal Control Engineer (joined Grumman '57), Charles Dunkerley, Thermal Control Engineer (joined Grumman February '63) and Dick Kline, Thermal Control Group Leader (joined Grumman '55) coordinate their efforts to perform thermal testing in this chamber.

At Grumman, the "Mix" of experience is broad. Here, also, are the up-to-the-minute facilities and challenging advanced programs for men seeking comprehensive professional development. Those seeking such an empirical environment will find responsible positions immediately available on advanced space programs.

Senior Heat Transfer Engineers—BS or MS with minimum of 5 years training and experience in structural heat transfer analysis is required. Will develop IBM programs and other analytical tools as needed to handle complicated configurations and end condition for space vehicle structures and propulsion systems. Must be capable of determining temperature distributions and recommended heat transfer configurations for initial structural designs and the detailed analyses, and test verification work to complete the design.

Temperature Control Engineers—BS or MS and 2 years experience to handle space vehicle temperature control system analysis. Should have background in radiative heat exchange and thermal coatings as applied to passive and active temperature control systems.

Senior Propulsion Aerodynamicists/Aerothermodynamicists — BS or MS with 5 years minimum experience in one or more of the following: Nozzles, Thrust Vector Control, Air Induction Systems, Reaction Jet Systems, Ducted Fans, Rocket Plumes, Pressurization Systems, Airborne Cooling, Boundary Layer Analysis and Control, Rotary Machinery Analysis, Ramjets, Exhaust Systems, Compressible Fluid Flow, Windtunnel Testing, Thrust Reversers, and Hypersonic Airbreathing Propulsion Systems.

Aerospace Environmental Control and Life Support Systems Engineers — BS or MS in fluid mechanics and/or thermodynamics with a minimum of 2 years experience in systems analysis design, development and testing of manned spacecraft systems.

Rocket System Performance Analysts — Degree in Engineering, Physics or Chemistry with a minimum of 3 years experience in Liquid Rocket Development, test and analysis. Knowledge of small pulsed rocket engines and pressure fed propellant systems is very desirable.

Propulsion System Analysts — BS or MS with a minimum of 3 years experience in rocket propulsion analysis and system simulation, using analog techniques. A good knowledge of liquid rocket feed systems, component characteristics, dynamic interactions, and vibration effects, is very desirable. Will be responsible for the development, test, and utilization of liquid rockets in manned space vehicles.

Reliability Test-Propulsion — BS in ME or equivalent with 5 years experience in propulsion system testing or design. Knowledge of rocket engines, preferably hypergolic type, required. Positions available for reliability planning and monitoring of propulsion test programs. Background in statistical analysis techniques desirable.

To arrange an immediate interview, SEND RESUME to Mr. P. M. Van Putten, Manager Engineering Employment, Dept. GR-86.

Grumman

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letters

Microelectronics Report

To the Editor:

I just finished reading the microelectronics roundup that you people had in your February 3 issue. This is indeed a monumental effort and a real service to the electronics industry in general. This is probably the most comprehensive single editorial effort on the present status of molecular electronics.

It is our intention to make this issue of MISSILES AND ROCKETS "must" reading for key divisional personnel—in particular, our field sales force.

Congratulations on a terrific job.

C. H. Knowles
General Manager
Molecular Electronics Div.
Westinghouse Electric Corp.
Baltimore

To the Editor:

Congratulations on your February 3 issue. Your staff did a good, comprehensive job in the Special Report on Microelectronics.

Edward O. Ethell
Vice President and
Assistant to the President
Autonetics
A Division of North American
Aviation, Inc.
Anaheim, Calif.

'Calculated Inconsistencies'

To the Editor:

As a long-time subscriber to your publication, I am often puzzled by what look to me like inconsistencies in the kinds of article titles you use. I've found titles in small letters, and titles in capital and small letters in the same issue. I've also noticed that some of the titles are underlined and others are not. Is there any explanation for these apparent inconsistencies?

George M. Bauer
Philadelphia

The "inconsistencies" referred to result from our policy of creating two distinct sections in each issue of MISSILES AND ROCKETS*—a news section and a technical section. All editorial material that appears before the Technical Countdown (page 21 in this issue) is considered news material. This includes departments such as The Countdown and The Missile/Space Week, in addition to major news stories (pages 14-19 in this issue). The major articles carry overlines to the "titles" or headlines. These are not underlined in the news section, as they are in the technical article section. In addition, the overlines in the news section are done in a different type face from the overlines in the*

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technical section. The latter categorize the article for the reader by identifying it as dealing with "space electronics," "space systems," "space propulsion," etc. We hope this explains that our "apparent inconsistencies" are real and, in fact, calculated, but that they are not actually inconsistencies.—Ed.

Capability Run Wild

To the Editor:

I sense that M/R tries hard to curb the excessive use of the word "capability." I hope you will do even better.

There is nothing more annoying, in reading a news or engineering story, than to see "the unit has the capability of . . ." (instead of "is capable of"—perhaps even "can"). The language of our trade is difficult enough without such indulgence in jargon at the expense of brevity and clarity.

Jean Duprez
Montreal

'Profile Of An Industry' Reprints

IN RESPONSE to widespread reader interest, MISSILES AND ROCKETS *has prepared reprints of the three-part "Profile of an Industry" series by Senior Editor William Beller. Based on recent surveys by U.S. Government agencies and the Stanford Research Institute (under a contract from the Aerospace Industries Association), the articles first appeared in the Oct. 28, Dec. 2 and Dec. 16, 1963, issues of M/R. Together they provide an unprecedented report on the growth of the Missile/Space industry—now the second largest employer in the United States—and its impact on the national economy and technology.*

The twelve-page reprint may be ordered from:

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Price of the reprint is $.50 (fifty cents) per copy.

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A look at 3 of over 30 current projects will indicate the scope of the operation:

☐ development of a new range instrumentation control system utilizing 3-kc K-carrier circuits which will reduce the response time and increase the data handling capacity of switching circuits between Cape Kennedy and downrange stations.

☐ improvement of precise digital timing generators and terminal shaping equipment so that correlation uncertainty across the Range will be less than 100 μsecs.

☐ installation of a new submarine cable between Cape Kennedy and Antigua to increase voice and telemetry data transmission capability.

Radiometric, Correlation, and Communications Engineers with EE or Physics Degree and applicable experience will find unusual diversity in the data support projects undertaken at the Atlantic Missile Range.

Address inquiries in confidence to Manager, Professional Employment, Dept. 56B-3

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*Vertical and Short Take-Off and Landing. Republic engineers and tacticians have been working with V/STOL designs for the past 10 years.

WASHINGTON

Space Missile Alarm Competes with Ground

One space-based system which may never get off the ground is the space-based attack alarm system (the re-oriented *MIDAS* program). In spite of improvements in infrared technology—particularly the reduced cryogenic requirements of the mercury-cadmium-telluride detector as compared with the mercury-doped germanium device (−193°C vs. −243°C), some defense officials feel that the new "over the horizon" radar would provide a cheaper and more effective system.

Strike Troubles at Houston, Too

NASA is hurting from labor problems elsewhere than at Cape Kennedy (see p. 10). Manned Spacecraft Center is scheduled to begin moving into its new Clear Lake site, near Houston, on Feb. 20, and to be installed at the new location by March 20. However, electrical workers are on strike in a dispute as to what constitutes electrical work in the Technical Services Building. MSC officials fear that unless the strike is settled, the work stoppage will spread to other buildings under construction—forcing postponement of the move.

Tory IIC Tests Slated Soon

Tory IIC—the second of a series of reactors expected to lead to a flyable low-altitude supersonic vehicle nuclear propulsion system—is scheduled to get its first tests at the AEC's Nevada Test Site early this year. Previous tests last October were suspended when deficiencies were discovered in expansion joints in the test facilities.

ARPA To Explore Ground Satellite Inspection

Funds are available in the current budget for a feasibility study of developing ground-based techniques for determining satellite characteristics. Study is to be conducted as part of ARPA's Defender program. Meanwhile, conceptual studies are under way on preliminary design of a manned spacecraft capable of co-orbital inspection of non-cooperative satellites. An important input will come from AF experiments to be carried aboard NASA's *Gemini* spacecraft.

Biosatellite Packages Chosen

NASA has finally made a decision on the first *Biosatellite* experiments. Fifteen have been selected as top priority, with another 30 close behind them. Letters to the experimenters are now awaiting the signature of Dr. Homer Newell.

First Gemini—Grissom and Armstrong?

There are unconfirmed reports that the first *Gemini* astronaut team will be made up of Virgil ("Gus") Grissom and Neal Armstrong. Grissom is the member of the original *Mercury* astronaut team who has worked most closely with McDonnell Aircraft Corp. in design and development of the spacecraft. Armstrong has chalked up many flight hours during the *X-15* program. Official announcement of the first pilot team is expected around May 1.

Zanzibar Deals Coup to Spaceflight

NASA is much more concerned than it will admit over the loss of its Zanzibar tracking station due to the uprising on that island. Prospect of a tracking ship is little comfort, considering the trouble it has been to get the Arnold and Vandenberg ready at Cape Kennedy—and the trouble that developed rather consistently aboard tracking ships during the *Mercury* program. Also questionable is the reliability of the ships during storms, which are bound to occur in the course of very long flights. On at least 50% of the orbits anticipated, the Zanzibar station was the last command station planned just before pilots had to fire retro-rockets. One possible solution would have NASA expand and make permanent an Air Force portable station on the Seychelle Island, east of Zanzibar just above the Equator.

INDUSTRY

TWA Batting 1.000 in Space League

Trans World Airlines made its first entry into the missile/space industry when it was selected by NASA to provide base support services at the John F. Kennedy Space Center. Twenty firms submitted proposals for the award, which is expected to cover three years. Value of the contract in the first year is estimated at $7 million. TWA's proposal was its first attempt to move into the aerospace field.

Garrett Wins Gemini Pressurization Job

Garrett Corp.'s AiResearch Manufacturing Co. division has been selected to design and produce an extravehicular pressurization ventilization system for *Gemini* astronauts. Primary objective of the cost-plus-incentive fee contract is development of a system that will provide a life-supporting environment within the *Gemini* pressure suit assembly during exposure to free space.

Second Little Joe II Heads for White Sands

General Dynamics/Convair is shipping the second *Little Joe II* booster to the White Sands (N.M.) Missile Range. It will be used to launch an *Apollo* boilerplate spacecraft in a ballistic flight early in the second quarter of this year.

Further Titan III Uprating Discussed

In addition to new upper stages or new propellants, Air Force is planning strap-on 156-in. boosters for *Titan III*. Such an arrangement could more than double the take-off thrust of the big booster. Other areas of "growth" potential include lengthening of the *Titan II* stages, uprating of the engines, and cutting of structural weight.

INTERNATIONAL

German Rocket Production Stopped

Weapons and Aviation Armaments Corp., a West German manufacturing group, will halt production of rockets it apparently planned to export to Middle Eastern Arab nations (M/R, Dec. 16, p. 21). The Feb. 7 halt presumably was ordered by the West German government, although WAAC officials told M/R the decision was made voluntarily, to avoid the government further embarrassment. The rockets built by WAAC apparently exceeded limitations placed on West German-made rockets by the 1954 treaty admitting that country to NATO. Word of WAAC's plans to export caused an international controversy culminating in a Soviet protest.

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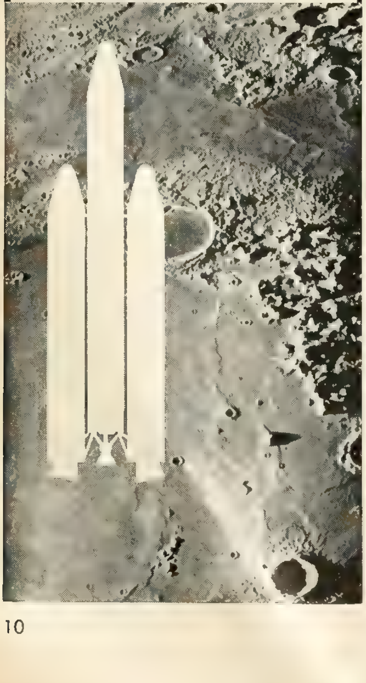

The Missile/Space Week

Athena Test Program Halted

Following failure of the first *Athena* test vehicle, the Air Force has ordered a halt to the program until the difficulties are isolated and corrected.

The 50-ft., 15,750-lb. *Athena* strayed off-course in an overland firing from Green River, Utah, to White Sands Missile Range, N.M. The vehicle landed some 50-75 miles off course, impacting 20 miles southeast of Durango, Colo.

Booster for the Air Force's *ABRES* (*Advanced Ballistic Reentry Systems*) program, *Athena* is a four-stage missile. In this test it carried a scaled version of the Mark 6 re-entry vehicle.

Failure appeared to be in the guidance package which, following second stage ignition, had falsely oriented the missile toward White Sands. Investigations are being conducted, however, to determine precisely what went wrong.

Cape Union Troubles Continue

Despite the fact that no pickets of the striking railroad telegraphers union appeared at Cape Kennedy last Wednesday, 1,844 of 3,560 construction workers employed at the Cape and Merritt Island stayed off the job. Some 3,200 did not report Monday and Tuesday.

Construction workers protested that non-union employees of the Florida East Coast Railroad were hauling in materials to be used in buildings at the space center.

The unions involved were given until Feb. 24 by a Federal judge to file a brief regarding charges of unfair labor practices brought against them by the National Labor Relations Board.

New Stabilizer Tested

A 10-lb. gravity-gradient stabilization system, flight-tested aboard a recently orbited Navy satellite, has proved highly successful. Telemetry data indicate the 5-in.-dia. sphere, boom extended after achieving orbit, stabilized the satellite to an accuracy of ±5 degrees within three days, well within design expectations.

Developed by General Electric's Missile and Space Div. at Valley Forge, Pa., the system makes use of the natural tendency of a spacecraft to self-align its longitudinal axis with the local vertical. In GE's approach, the stabilization system employs the Earth's gravitational field for spatial orientation and the Earth's magnetic field to assist in damping the resulting oscillations.

Details concerning the Navy Research Laboratory-developed satellite and its other experiments are classified. (Launched into a near-circular, 900-mi.-altitude orbit on Jan. 11, 1964, it is known simply by its code designation, GGSE (probably for Gravity-Gradient Stabilization Experiment).)

GE engineers disclosed that while its system (using two boom/spheres) is capable of three-axis stabilization, the current test provides only for pitch and roll control. The damping mechanism (5-in. sphere) consists of two concentric shells, separated by a thin layer of oil. The inner shell has a fixed bar magnet running through its center and six horseshoe magnets symmetrically fixed about the inner surface.

Hercules Wins HIBEX Award

Hercules Powder Co. has been selected by the Boeing Co. to develop the solid motor for the *HIBEX* (*High-G Boost Experiment*) vehicle. Amount of the award was not revealed.

HIBEX is an ARPA-sponsored program to explore extremely high acceleration missiles for A-ICBM use. The two-year program, initially funded at $6 million, will involve building and firing an undisclosed number of missiles. The firings will be conducted at White Sands Missile Range, N.M.

JFK Center Reorganized

A major staff reorganization has taken place at NASA's Kennedy Space Center.

Dr. Kurt Debus, center director, said the move was made to improve management functions, particularly those concerned with manned spaceflight programs.

Principal change is designation of five assistant center directors for Program Management, Administrative Management, Launch Vehicle

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Program Management is split into two major areas, *Apollo* Program Management and the Programs Support Office. Lt. Col. Rocco Petrone will serve as assistant director for Program Management and head the *Apollo* Program Management Office.

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July, 1957.

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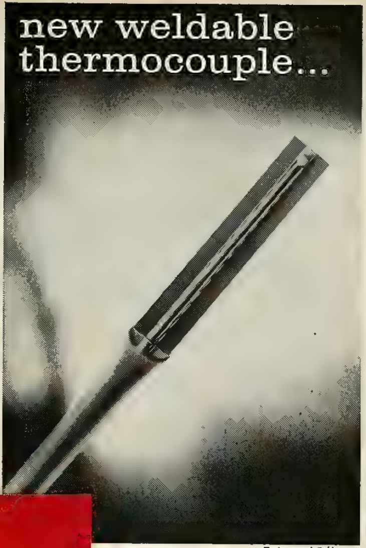

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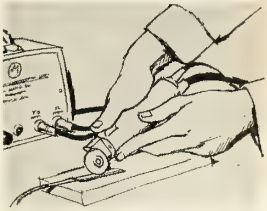

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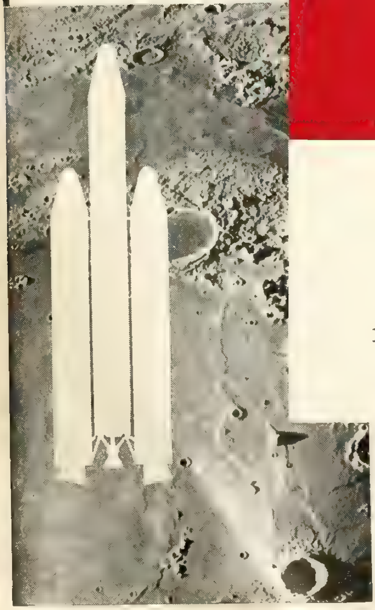

The Missile/Space Week

Athena Test Program Halted

Following failure of the first *Athena* test vehicle, the Air Force has ordered a halt to the program until the difficulties are isolated and corrected.

The 50-ft., 15,750-lb. *Athena* strayed off-course in an overland firing from Green River, Utah, to White Sands Missile Range, N.M. The vehicle landed some 50-75 miles off course, impacting 20 miles southeast of Durango, Colo.

Booster for the Air Force's

Forge, Pa., the system makes use of the natural tendency of a spacecraft to self-align its longitudinal axis with the local vertical. In GE's approach, the stabilization system employs the Earth's gravitational field for spatial orientation and the Earth's magnetic field to assist in damping the resulting oscillations.

Details concerning the Navy Research Laboratory-developed satellite and its other experiments are classified. Launched into a near-circular, 900-mi.-altitude orbit on Jan. 11, 1964, it is known simply by its

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data indicate the 5-in.-dia. sphere, boom extended after achieving orbit, stabilized the satellite to an accuracy of ±5 degrees within three days, well within design expectations.

Developed by General Electric's Missile and Space Div. at Valley

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Lt. Col. Raymond L. Clark will bear the newly-created title of Assistant Director for Technical Support Operations.

Responsibilities of Karl Sendler, assistant director for Instrumentation, remains unchanged, but three offices in his area have become divisions.

DOD Seeks More Cost Cuts

The Dept. of Defense has asked its 100 top contractors and major industry associations to set up voluntary cost-reduction programs with 12-month goals and 6-month reports to the government on actual savings.

DOD officials, in the middle of a cost-cutting drive within the department, said that future procurement actions would "take into account" the cost-saving accomplishments of defense contractors.

The Pentagon asked the companies and associations to submit comments on its proposal within 30 days. A four-page guideline will then be inserted into procurement regulations.

Shots of the Week

First shot of an *Athena* re-entry vehicle in the Air Force's *Advanced Ballistic Re-entry Systems (ABRES)* program failed when the payload came to Earth 50-75 mi. short of the White Sands Missile Range, N.M., target (see p. 10).

- The Air Force successfully launched its 30th *Minuteman* ICBM from Vandenberg AFB, Calif., Feb. 11. The firing was termed a "routine training" shot by the Strategic Air Command.
- The Air Force on Feb.. 12 launched an *Atlas F* ICBM from Vandenberg AFB, Calif. Launch was a routine training mission and was termed a success.
- The Air Force successfully launched a *Minuteman* from Cape Kennedy Feb. 12. Shot was first in a series of tests of the *Minuteman's* penetration aids.

Comsat Situation Report

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At the same time, the White House and the corporation separately presented to Congress the first annual reports on the communications satellite program.

Essentially alike, the reports announced a plan to launch one or more synchronous satellites in 1965 on an experimental basis. If successful, the satellites would become operational. Comsat is expected to request FCC authorization for this program soon.

Companies meeting the Feb. 10 deadline with proposed designs for an international communications satellite included Hughes Aircraft Co.; Philco Corp.; Thompson Ramo Wooldridge, Inc., with International Telephone and Telegraph Corp. as prime subcontractor; and American Telephone and Telegraph Co. and Radio Corp. of America as joint contractors.

From the four proposals, Comsat will award six-month contracts for design and engineering work on both medium- and high-altitude satellite systems, probably within a few weeks. It will then grant a production contract for one basic system, which it hopes to have operational by 1966.

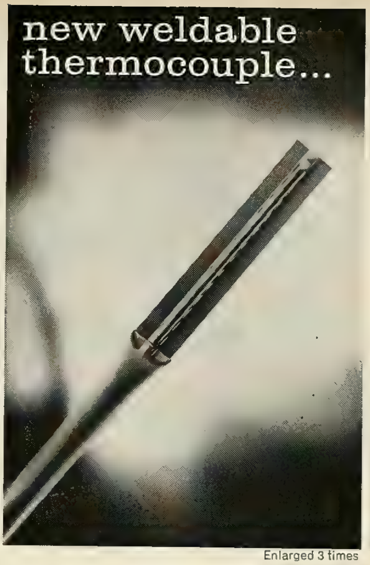
Saenger Dies in Berlin

Dr. Eugene Saenger, one of Europe's foremost space scientists and father of the *Dyna-Soar*, died last week in West Berlin.

The 58-year-old rocket expert was best known for his World War II work on a rocket-powered global-range bomber (*Dyna-Soar* concept) and for his post-war theoretical studies of photon-powered rockets.

Saenger had been a member of MISSILES AND ROCKETS editorial advisory board since July, 1957.

At the time of his death, Saenger was professor of space travel at Berlin Technical University, a post he had held since last May.



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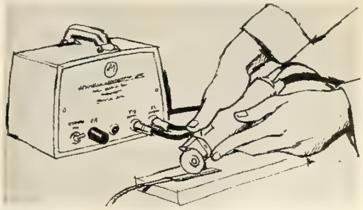

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MMRBM Faces New Budget Slash

Cut of $35 million reported; Joint Chiefs still backing program despite civilian disinterest; R&D funds trimmed

by Heather M. David

A CRIPPLING BLOW to the Air Force's *Mobile Medium Range Ballistic Missile (MMRBM)* may be dealt by budget cuts reportedly made in the House Armed Services Committee.

It now appears that the oft-beleaguered program—though just a few weeks ago reported to be entering Phase II contract negotiations—may run into trouble again this year.

It is understood that the Armed Services Committee has cut the request—estimated at about $110 million for Fiscal Year 1965—by approximately $35 million. Evidence indicates this could be the proverbial last straw.

Although Secretary of Defense Robert S. McNamara in recent weeks has given verbal support to the program, it appears that the real proponents continue to be the Joint Chiefs of Staff. It is reported that some "foot-dragging" within the Defense Dept.'s civilian hierarchy continued through the end of last year, and the development contracts promised contractors in January have not been signed.

Basic reservations concerning *MMRBM* remain the same as those voiced last year, when the program barely escaped being stamped out by the House Appropriations Committee. At that time, McNamara indicated he would not ask for restoration of the funds in question, but that the Joint Chiefs themselves were making this request. On this basis, the Senate Appropriations Committee restored much of the funds, believing that this would put the program back on the line. In fact, McNamara filed a letter with the committee promising to go ahead with Phase II (development) if the funds were restored.

Capitol Hill sources feel that if the program is cut again this year, the Secretary may make no effort to save it.

The basic reservations held by the policy-makers appear to be the same. There is no approved plan to deploy the *MMRBM* in European countries, and it is reported that no negotiations have been entered into. In addition, there are many who feel that there are alternative, perhaps cheaper, approaches to the job. *Polaris* remains a favorite in this category.

● **Other cuts**—The House Armed Services Committee, chaired by Rep. Carl Vinson (D-Ga.) left the procurement portion of the DOD authorization request intact, but cut the research and development portion by a total of $362.5 million.

These cuts were:

—$62 million in Army funding, bringing it to $1,335,000,000.

—$121.5 million in Navy and Marine Corps R&D, bringing that figure to $1,329,500,000.

—$157 million from the Air Force R&D budget. However, the R&D subcommittee headed by Rep. Melvin Price (D-Ill.) added an additional $52 million for the Follow-on Bomber, and $40 million for the Improved Manned Interceptor. This brings the total AF R&D to $3,140,000,000.

—$22 million for the Defense Agencies, bringing their budget to $497,000,000.

The additional $92 million for Air Force aircraft makes the net reduction in the total bill $270.5 million. Thus, the request was $17,185,300,000 and the bill which will go to the House floor early this week is $16,914,800.000. ■

Joint Committee Insisting on SNAP Flight Tests

THE JOINT Atomic Energy Committee has given notice that it will authorize funds to the Atomic Energy Commission for flight-testing SNAP reactors in spite of Defense Dept. withdrawal of support.

Sen. John O. Pastore (D-R.I.) and Rep. Chet Holifield (D-Calif.), co-chairmen of the JAEC, sent letters to Air Force Secretary Eugene Zuckert, NASA Administrator James E. Webb, AEC Chairman Glenn Seaborg and Budget Director Kermit Gordon indicating this intention and requesting them to "get together" to make certain that the SNAP programs are conducted during the remainder of FY 1964 with this in mind.

The chairmen expressed extreme concern over the fact that DOD has pulled the rug out from under SNAP by announcing that it has "no stated requirement" just before flight tests could have been conducted.

AEC officials testifying last week also indicated they were stymied by the Bureau of the Budget, which refused a request for $15 million to flight-test SNAP 10A, trimmed $7 million from SNAP 50, and cut back the systems improvement fund by $5.5 million. Thus, JAEC action will provide funds in excess of AEC's request for this program.

● **By numbers**—The status of the SNAP reactors, according to AEC:

—SNAP 2—System development is being dropped, even though $59 million has been spent on the program, because there is no mission requirement.

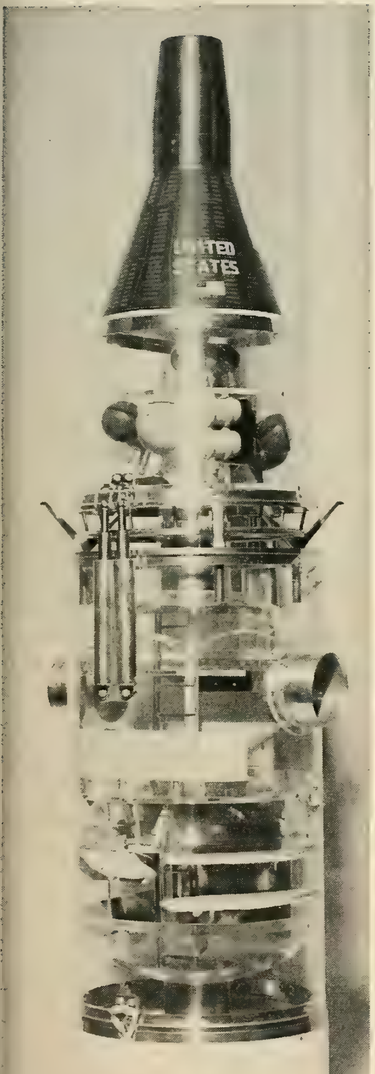
—SNAP 4—Being dropped. No specific DOD requirement.

—SNAP 10A—Flight-test objective is being cancelled. AEC will reorient the hardware to a ground system, which it will try to run for a year or longer. $53 million has been spent, flight tests would cost $15 million a year for two years.

—SNAP 50—There has been a major cutback in development effort.

SNAP 8—The only version in which NASA is participating appears to be in good shape, with delivery expected about 1968. In addition, the isotopic sources (7, 9, 13) are performing well and a 25-watt source is now in orbit. AEC said this program is now moving toward a 60-70-watt capability.

By Douglas, GE, Martin . . .



MODEL of one of proposed MOL concepts shown by AF Space Systems Div. at recent meeting in San Antonio.

OSS Studies Will Start Definition of the MOL

Results will be combined with those from in-house AF studies to provide basis for RFP's possibly this fall

by James Trainor

AWARD of three contracts for study of the *Orbiting Space Station (OSS)* is a "significant first step" in definition of the *Manned Orbiting Laboratory (MOL),* an Administration official told MISSILES AND ROCKETS last week.

OSS studies are expected to accomplish "the fundamental homework for an extended manned spaceflight" capability, he said.

Specifically, he explained, the studies will define man's "military charter" in space, the systems needed to fulfill that charter and the development efforts necessary to acquire those systems. As an integral part of systems acquisition, the companies are to determine which equipments can be tested on the ground or in aircraft and which require testing in space.

Douglas Aircraft Co., General Electric Co., and Martin Co., will conduct the four-month studies for the Air Force. Although not yet officially announced by the Defense Dept., the contracts are expected to be worth $1,000,000 each.

- **Tie-in with MOL**—Part of the immediate task "to detail, by thorough study, what is to go into the *(MOL)* program," the *OSS* studies together with in-house studies by the Air Force are expected to provide the basis for the *MOL* requests for proposals.

The RFP's, therefore, are not expected to go to industry before the fall of this year. With a minimum of 60-90 days for reply, program definition contracts are not likely to be let until late this year or early 1965. A contract for development of *MOL* on this timetable could be awarded in the spring of 1965.

This "business-like approach" to *MOL,* an official source says, is indicative of DOD's building-block philosophy toward development of space technology. *Titan III,* he points out, was the result of the same type of program; although DOD could not foresee specific applications, it went ahead with the program as future "insurance."

- **What is MOL?**—Since the Dec. 10 announcement by Defense Secretary Robert S. McNamara that he was initiating the *MOL* program, many contradictory and misleading stories about the program have appeared in the press.

Yet, as Dr. Albert C. Hall, DDR&E Deputy Director for Space, told the Military Electronics convention last week, "at this point in time what we are calling *MOL* is a concept rather than a specific piece of hardware." Or, as another Administration source pointed out, many of the questions about MOL can't be answered.

MOL's true significance at this point, one source said, is that it is indicative of "a re-orientation or re-definition of DOD space activities" toward the need for an early, effective demonstration of man's utility in performing military functions in space.

Recognizing that the lead times for manned military space systems may be 10 years or longer, the MOL would provide the basis for specifying design characteristics and performance parameters for operational systems in the mid-1970 time period.

MOL will consist of the modified *Gemini B,* formerly *"Gemini X,"* and a compartmentalized Mission Test Module (MTM) with a volume of approximately 1,500-2,000 cu. ft.

The first manned flight of *MOL* will be launched by the *Titan III-C* in late 1967 or early 1968. The number of flights has not been determined as yet. However, it is likely that there will be several unmanned and manned flights of *Gemini B* in 1966 and several *MOL* flights in 1968 and 1969.

Total cost of the program is difficult to estimate at this point, one source noted. In an open-ended program of this type, however, the program cost probably would be "$1 billion plus—certainly more than *Gemini."* NASA estimates *Gemini's* cost at $1.053 billion. ■

In wake of Ranger VI . . .

Space Agency Wants JPL To Reorganize

Troubles haunting lunar, planetary programs trigger efforts in contract renegotiation to get 'hard-headed' management

by Hal Taylor

NASA IS TRYING to force a reorganization of the Jet Propulsion Laboratory to get what is termed a "hard-headed type of industrial management" for its trouble-plagued lunar and planetary spacecraft programs.

Administrator James E. Webb declared last week that the agency is currently renegotiating its contract with JPL. One of the things NASA wants is better management.

At the same time, Webb revealed a probable cause for the failure of the TV camera system during the *Ranger VI* flight.

He said that there was an unscheduled turn-on of the cruise telemetry system about 2½ minutes after launch and about the same time as the separation of the *Atlas* booster engines.

The telemetry was on for about one minute.

"Why this happened we don't know at this time, but one possibility is that the television system turned on at the same time. If that happened, severe electrical arcing would have occurred and damaged the equipment."

● **Apollo stretchout admitted**—Webb's comments were made at a press conference where he also stated that:

—He thought it unlikely that the *Ranger VII* spacecraft would be launched during the next possible launch window, Feb. 28 to March 5. A final determination of the next *Ranger* flight plan will have to await the report of the special board currently studying the cause of the *Ranger VI* failure.

—There has been a change in U.S. thinking that landing a man on the Moon by the end of the decade is an absolute deadline. The development of a U.S. space capability, he said, "has entered into a stretchout, a pushing into the future of the program." He maintained, however, that NASA still has a fighting chance to meet the goal.

—Earliest possible date for joint U.S.-USSR experiments with the *Echo II* passive communications satellite now in Earth orbit is Feb. 21. The Russians also made photometric and photographic observations of the *Echo II* satellite during its first passage over the Soviet Union shortly after its launching Jan. 25. They have given U.S. scientists preliminary reports of their observations.

In discussing JPL management of the *Ranger* program, Webb praised the laboratory's previous contributions to the U.S. space effort.

He also pointed out that the successful *Mariner* fly-by of Venus was a product of JPL.

● **Better relationships sought**—He said, however, that NASA and JPL have learned a great deal about the management of the lunar and planetary unmanned spacecraft programs under the current three-year contract.

"It expires next June and we have now for some months been examining together with the California Institute of Technology (of which JPL is a part) ways and means to make a better relationship from their standpoint and from NASA's standpoint."

He added that one of the very important problems that NASA and JPL have is how to marry industrial resources that have a good deal of know-how "in these fields" with laboratories managed by universities.

Webb refused to say how NASA hoped to achieve "hard-headed" industrial-type management, noting only that Earl Hilburn, Deputy Associate Administrator for Industrial Affairs, is negotiating the problem with JPL officials.

Walter L. Lingle, deputy to Associate Administrator Dr. Robert C. Seamans, Jr., said NASA does not want JPL to select an industrial contractor to manage its program.

● **Improving management**—He said that NASA wanted to see industrial-type management achieved "right down through the whole organization." He said that this would entail clarification of the lines of authority and some sort of follow-up system to insure accomplishment of goals. "They don't have that kind of capability now and we think they have to develop it," he said.

The agency announced that in the *Ranger VI* inquiry it is probing the reason for the unscheduled telemetry turn-on and is trying to determine if the television system also turned on at this time, causing severe electrical arcing and camera damage.

Webb said that if the reason for the failure is not found, the agency may have to launch a heavily instrumented *Ranger* in an attempt to find the cause of possible future in-flight failures. ■

Apollo Propulsion Under Study

A NEW HIGH-ENERGY propulsion system for the *Apollo* spacecraft Service Module using a single Pratt & Whitney RL-10A3 engine is being studied by NASA officials.

The NASA scientists report that the system could reduce the service module weight by 15 to 20% and permit a corresponding increase in the weight of the Command and Lunar Excursion modules of 1,400 to 1,500 lbs.

Whether such a backup system is undertaken will probably depend upon how much of the agency's FY '65 budget request is approved by Congress. A decision is not expected for a month or two.

Manned spaceflight officials believe that the current system, which uses storable propellant, is adequate for the manned lunar landing flight. They point out, however, that for follow-on missions, more payload capability will be needed. The liquid hydrogen high-energy system, they contend, could provide this.

The system would require a different type of service module because of the fuel tanks needed, but the structure and outer skin would remain the same.

House Group To Seek Further Justification of Electronics Center

FURTHER HEARINGS on the proposed NASA Electronics Research Center will be held by the House Space Committee sometime in the next two weeks.

Although Chairman George P. Miller (D-Calif.) described the report to Congress submitted by NASA Administrator James E. Webb as "very comprehensive," he said the committee will ask more questions on the need for the center.

The Senate Space Committee has made copies of the report available to a number of Senators—including a number not on the committee.

Congress is now 17 days into a 45-day period in which action can be taken on the proposal. If the time passes with no adverse action by either committee, approval is signified.

• **Weighty tome**—The NASA report, which measures about an inch thick and weighs almost two pounds, was submitted to the committees Jan. 31. In the covering letter, Webb said "the new study . . . has sustained and strengthened the conclusion that such action is vital." He said the mission of the center would be to: 1) carry out a program of in-house research designed to attack important research areas and to meet specific requirements of providing the basis for the assembly of a staff of highest technical competence (budget is estimated at $35 million at full capacity, up to one-half of which would cover personnel, equipment and support costs); 2) originate and manage a program of grants and contracts in universities, institutes, and industry in support of necessary areas of advanced research ($42 million at full operation); 3) work closely with NASA centers having responsibility for various systems of boosters and spacecraft. These contracts for operational systems will continue to be managed by the responsible center, the report stressed.

While the Boston area decision is described as "tentative," steps are already being taken in anticipation of approval. The Air Force announced last week that it is studying a suggestion to close down its base at Bedford, Mass., with the idea that the NASA center could be located there. The base's functions would then be transferred to Griffiss AFB, Rome, N.Y., which otherwise will be closed down in a DOD economy move.

A New York Congressional delegation of Sens. Jacob Javits and Kenneth Keating and Rep. Alexander Pirnie had made the proposal, which will be presented to NASA.

Webb said that NASA had examined the possibility of utilizing existing government laboratories, and that none had been found which could absorb such a center. "The new Center must be able, from a hard management viewpoint, to plan and manage the NASA electronics research program, both that carried out within NASA and that performed by competent groups throughout the nation under contract, to insure its effectiveness," he said.

• **The choice**—As the committee's work progressed, Webb said, 12 areas were studied as having outstanding resources. These were Ann Arbor-Detroit, Baltimore, Boston, Chicago, Los Angeles, Minneapolis-St. Paul, New York, Philadelphia, Pittsburgh, Princeton, the San Francisco Bay area, and St. Louis. Those which did not already have NASA centers (nine) were included in detail in the report.

Boston was chosen, Webb said, as having the best qualifications:

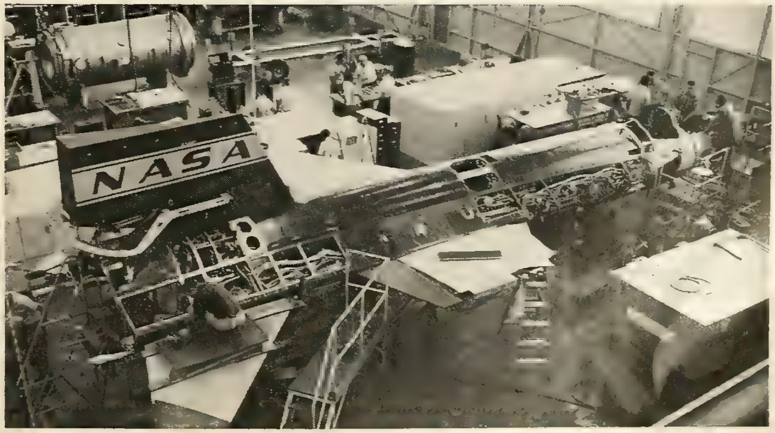
—The Massachusetts Institute of Technology and Harvard University, providing a basic core of "the highest quality of advanced research, scholarship, and training in the scientific fields of primary interest."

—A number of other public and private laboratories which "attract people from the world over to this vital source of advanced thought and research in electronics."

—A number of other good universities nearby, "providing assurance that all levels and patterns of education will be available for the Center personnel within a relatively small and entirely practical geographical area." ■

Advanced X-15 on Line At North American-LA

ADVANCED X-15 rocket plane nears completion at Los Angeles Div. of North American Aviation. Being rebuilt from ship No. 2, which crashed in November, 1962, it is slightly longer than its predecessor and carries external fuel tanks for ramjet engine tests. The X-15 program has gained in importance for near-space research, following cancellation of the X-20 Dyna-Soar program shortly before Christmas last year.



In FY '65 budget . . .

Manned Network Gets Major Push

$100 million would be big step toward operational system by 1967; space agency, DOD sign tracking ship agreement

NASA WILL SPEND more than $100 million in FY '65 for tracking and data-acquisition equipment for its manned spaceflight network.

The funding request is part of a major drive to make the network operational by 1967.

At the same time, NASA and the Defense Dept. announced an agreement covering new tracking ships for Project *Apollo*.

Details of the agreement, first reported in MISSILES AND ROCKETS (Dec. 16, 1963, p. 17), call for three new tracking ships to be built and two others to be modified. The ships will become part of this country's tracking ship fleet of 20, which will be operated by DOD. The space agency, however, will procure ship instrumentation required for the manned lunar landing program.

There are now 17 instrumentation ships. Two of these will be modified for Project *Apollo*. Three more ships, taken from the Maritime Reserve Fleet, also will be converted for tracking and data acquisition in Project *Apollo*.

- **Ship agreement details**—The agreement specifies that DOD will have custody of the ships and be responsible for their management, operating them on behalf of both DOD and NASA.

Responsibility for design, construction and modification of the instrumentation ships will be centralized under the Navy Dept., which has established an Instrumentation Ship Project Office. The director of this office will have Air Force and NASA deputies.

NASA will provide performance specifications for instrumentation required for the *Apollo* mission and design specifications for equipment that must be standardized for the *Apollo* network. DOD technical crews on ships supporting NASA manned spaceflight missions will be trained to NASA-approved specifications and standards.

New ships needed for *Apollo* and alterations on existing ships to equip them for *Apollo* support will be funded by NASA. DOD will fund any general-purpose or special-purpose capability in addition to requirements for *Apollo* as well as continuing modernizations and improvements.

The Military Sea Transportation Service will be responsible for ship operation, and the DOD range agencies will be responsible for scheduling and ship instrumentation operation.

- **Apollo network composition**—The *Apollo* tracking network will eventually be composed of nine stations with 30-ft. antennas, three 85-ft. antenna sites, one insertion ship, two ships for coverage of the early translunar coast period, two re-entry ships and aircraft for injection coverage.

Details of the $106.9-million request for equipment for the manned network were disclosed in budget documents presented to Congress. (See opposite page for detailed breakdown.)

The manned spaceflight portion is more than one-third of the total FY '65 space agency tracking and data-acquisition development program.

Other major equipment purchase programs included $15.9 million for the satellite network and $12 million for the deep space network.

- **Modular design**—In discussing the manned network, the agency told Congress that the final configuration of all network stations to be used in support of the *Apollo* program will incorporate in the unified S-band complex the necessary receiving, transmitting, ranging, antenna, command, demodulation and data-handling systems.

A modular building-block approach will be used. This approach, which will make use of the same subsystems in all stations even though this number varies at some stations, will reduce maintenance, replacement and training costs.

Receiving systems, which are identical except for small changes in frequency and bandwidth to those of the deep space network, will provide the initial demodulation of voice and telemetry, provide Doppler tracking and emit signals for antenna directing.

The command systems and data-handling systems are of the same design for *Apollo* as for *Gemini* and will be procured only for those stations not now augmented for *Gemini*. ■

NASA Plans New H-F Engine Study

NASA WILL START a preliminary design study of an advanced hydrogen-fluorine engine in FY '65.

The new engine will be based on the results of a current experimental fluorine technology program with the RL-10 engine. If approved for development, the new engine would be used in the high-energy upper rocket stage being pushed by some NASA officials.

A breakdown of the budget of the Office of Advanced Research and Technology also reveals that the 1.5-million-pound-thrust liquid hydrogen M-1 program will be restricted almost completely to component development over the next two years.

The space agency told Congress that in FY '65 only limited effort will be made in engine systems work. It expects, however, to complete most of the engine design work and begin testing of most major engine components in the next fiscal year.

NASA's $165-million propulsion research effort accounts for more than one-half of OART's total budget request of $282 million. Other details revealed in the budget breakdown include:

—The $18 million requested for the SNAP-8 system would allow starting test operations on two complete prototype power-conversion subsystems for design verification, calibration and evaluation work.

—The $34.5-million request for the NERVA nuclear engine will be used for fabrication and assembly of a cold-flow development test system. The tests will precede full-scale nuclear engine system tests.

DETAILED BREAKDOWN OF NASA FY '65 R&D BUDGET REQUEST FOR OFFICES OF ADVANCED RESEARCH AND TECHNOLOGY AND TRACKING AND DATA ACQUISITION

(in millions of dollars)

ADVANCED RESEARCH & TECHNOLOGY

	FY '64	FY '65
BASIC RESEARCH SUPPORTING RESEARCH AND TECHNOLOGY	**$21.000**	**$21.000**
Fluid physics	7.820	7.800
Electrophysics	3.960	4.000
Materials	8.020	8.000
Applied mathematics	1.200	1.200
SPACE VEHICLE SUPPORTING RESEARCH AND TECHNOLOGY	**26.300**	**26.300**
Spacecraft aerothermodynamics	5.432	5.432
Spacecraft loads and structures	5.177	5.177
Launch vehicle aerothermodynamics	0.914	1.214
Launch vehicle loads and structures	3.797	3.797
Space vehicle environmental factors	7.030	7.030
Advanced space vehicle concepts	2.650	2.350
Space vehicle design criteria	1.300	1.300
SCOUT RE-ENTRY EXPERIMENTS	**1.500**	**2.000**
Spacecraft and support services	0.500	1.000
Launch vehicles	1.000	1.000
PROJECT FIRE	**8.000**	**3.000**
Spacecraft and support services	6.470	1.890
Launch vehicle	1.530	1.110
SATURN-LAUNCHED METEOROID EXPERIMENTS	**8.000**	**2.600**
Spacecraft and support	8.000	2.600
SMALL SPACE VEHICLE FLIGHT EXPERIMENTS	**2.800**	**3.000**
Behavior and handling of cryogenic propellants at zero G	1.050	0.640
Wind shear measurements	0.200	0.200
Meteor simulation	0.750	0.610
Re-entry detection	0.200	0.150
Meteoroid penetration probe	0.100	—
Secondary environmental experiments	0.500	1.400
LIFTING BODY FLIGHT AND LANDING TESTS	**0.900**	**1.900**
Flight vehicle and support services	0.900	1.900
ELECTRONIC SYSTEMS SUPPORTING RESEARCH AND TECHNOLOGY	**24.900**	**25.400**
Guidance systems	5.265	5.485
Control systems	4.850	5.460
Communications	4.315	4.445
Tracking and data acquisition	3.220	3.060
Data handling and processing	3.530	3.380
Instrumentation	3.720	3.560
SMALL FLIGHT PROJECTS	**3.800**	**3.000**
Radio attenuation measurements (RAM)	2.000	2.000
Scanner	1.800	1.000
Spacecraft orientation control system (SCCS)	—	—
HUMAN FACTORS SYSTEMS	**13.200**	**16.200**
Supporting research and technology	13.200	13.200
Flight program: small biotechnology flight projects	—	**3.000**
NUCLEAR ELECTRIC SUPPORTING RESEARCH AND TECHNOLOGY	**24.600**	**25.000**
NUCLEAR ELECTRIC POWER	**(12.600)**	**(13.000)**
Space environment effects	0.931	0.840
Liquid metal and metal vapor properties and technology	3.517	3.900
Gaseous systems and components	1.512	1.180
Dynamic systems and components	3.336	3.880
Direct conversion	1.694	1.700
Advanced concepts and mission analysis	1.610	1.500
ELECTRIC PROPULSION	**(12.000)**	**(12.000)**
Electrostatic propulsion	5.662	5.700
Electrothermal propulsion	1.623	1.700
Electromagnetic propulsion	2.330	2.500
Component technology	2.385	2.100
SNAP-8 DEVELOPMENT	**15.500**	**18.000**
Development and flight projects	15.500	18.000
SPACE ELECTRIC ROCKET TEST (SERT)	**4.000**	**5.100**
Spacecraft design, development and support	4.000	5.100
Launch vehicles	—	—
NUCLEAR ROCKET SUPPPORTING RESEARCH AND TECHNOLOGY	**21.200**	**23.000**
Rocket reactor research	12.265	13.100
Nuclear rocket engine component research	7.635	8.300
Safety	0.500	0.500
Vehicle technology	0.800	1.100
KIWI	**1.500**	—
Reactor test support components	—	—
Propellants	1.500	—
NERVA	**52.000**	**34.500**
Engine systems development	7.900	3.500
Component and subsystem development	20.300	18.500
Propellants	3.000	3.000
Ground test and operations support	20.800	9.500
NUCLEAR ROCKET DEVELOPMENT STATION OPERATIONS	**0.500**	**0.500**
General site support	0.100	0.100
Facility checkout and maintenance	0.350	0.350
Capital equipment	0.050	0.050
CHEMICAL PROPULSION SUPPORTING RESEARCH AND TECHNOLOGY	**21.800**	**21.800**
Analysis, aerothermochemistry Heat transfer and materials	5.892	5.983
High energy propellants	7.225	7.414
Liquid rocket engines	6.640	6.000
Solid rocket motors	2.043	2.404
EXPERIMENTAL ENGINES	**24.000**	**38.000**
Large solid motor demonstration	—*	13.000
M–1 Engine	24.000	25.000
SPACE POWER SUPPORTING RESEARCH AND TECHNOLOGY	**13.000**	**13.000**
Photovoltaics	2.750	2.750
Thermionics and thermoelectrics	1.750	1.750
Solar dynamic systems	4.850	4.850
Batteries, fuel cells and engines	3.650	3.650
TOTAL	$320.200	$320.300

*previously an Air Force program.

TRACKING AND DATA ACQUISITION

	FY '64	FY '65
TRACKING AND DATA-ACQUISITION SUPPORTING RESEARCH AND TECHNOLOGY	**$12.000**	**$15.500**
New systems development	2.995	3.100
Integrated systems analysis, development and test	1.361	2.090
Improvement to existing systems	7.644	10.310
NETWORK OPERATIONS	**81.500**	**99.800**
Satellite network	22.000	25.600
Manned flight network	20.200	25.400
Deep space network	12.000	14.600
Wallops/Fort Churchill instrumentation	5.000	5.300
Aerodynamics test range	0.800	0.800
Network communications	15.000	18.700
Data processing and handling	6.500	9.400
EQUIPMENT AND COMPONENTS—SATELLITE NETWORK	**16.800**	**15.900**
Tracking systems	1.696	2.161
Telemetry systems	4.409	3.465
Command and control systems	1.242	1.912
Recording and display systems	2.386	2.040
Test, calibration and monitoring equipment	0.871	0.806
Spacecraft checkout equipment	1.269	0.104
Timing systems	0.740	0.690
Real-time data-handling systems	0.500	0.975
Special-purpose equipment	0.510	1.175
Power systems	0.495	0.160
Maintenance, spares and replacements	2.682	2.412
EQUIPMENT AND COMPONENTS—MANNED SPACE FLIGHT NETWORK	**69.600**	**106.900**
Apollo		
Receiving systems	12.379	15.472
Transmitting systems	3.223	6.986
Ranging systems	0.980	2.156
Antenna systems	15.103	5.106
Command systems	1.600	3.000
Demodulation systems	6.000	19.700
Data-handling systems	8.406	12.284
Re-entry ship modifications	—	17.400
Aircraft modification and design	0.150	18.420
Maintenance, spares and replacement	1.252	3.905
Gemini		
Data processing systems	5.050	—
Data handling systems	6.040	—
Command systems	2.195	—
PCM telemetry systems	4.535	—
Maintenance, spares and replacements	2.717	2.471
EQUIPMENT AND COMPONENTS—DEEP SPACE NETWORK	**11.500**	**12.000**
S-band receiver, transmitter and components	2.936	2.897
Atomichron and synchronization equipment	0.115	0.115
Klystron and maser amplifiers	1.045	0.815
Antenna and servo modifications	1.264	1.985
S-band ranging and acquisition systems	1.155	1.297
Digital data and instrumentation systems	0.985	1.175
Data transmission and processing equipment	0.570	0.495
Test transponders and calibration systems	0.745	1.225
Recording systems	0.980	—
Maintenance, spares, replacements and documentation	1.775	1.996
EQUIPMENT AND COMPONENTS—WALLOPS AND OTHER INSTRUMENTATION	**2.700**	**3.900**
Photographic processing equipment	0.220	0.200
Range camera equipment	0.250	0.550
Aircraft calibration and test instrumentation	0.160	0.350
Antenna systems modifications	0.240	0.180
Timing equipment	0.075	—
Range ship instrumentation	0.080	—
Data systems	—	0.420
Telemetry system components	—	1.100
Radar system components	—	0.450
Maintenance, spares and replacements	1.675	0.650
EQUIPMENT AND COMPONENTS—AERODYNAMIC TEST RANGE	**1.000**	**1.500**
Tracking systems	0.750	0.100
Telemetry systems	—	0.600
Real-time data-handling systems	—	0.250
Maintenance, spares and replacements	0.250	0.550
EQUIPMENT AND COMPONENTS—COMMUNICATION	**3.600**	**3.300**
Data terminal equipment	0.195	0.555
Solid-state switching units	2.735	1.662
Switching center equipment	0.150	0.200
Teletype and voice equipment	0.220	0.528
South American systems modification	—	0.055
Test and evaluation equipment	0.150	0.200
40 kw radio transmitters	—	—
Mobile communications vans	—	—
Maintenance, spares and replacements	0.150	0.100
EQUIPMENT AND COMPONENTS—DATA PROCESSING AND HANDLING	**11.200**	**9.100**
Digital computing subsystems	4.950	2.500
Off-line data processing systems	1.800	2.300
Peripheral equipment	0.720	1.250
Data processing subsystems	1.925	0.880
Signal conditioners	—	0.550
Special-purpose data processing and display	0.715	0.450
Automatic analog data tape evaluation equipment	0.590	0.325
High-density storage and record units	—	0.270
Test and evaluation equipment	0.075	0.100
Maintenance, spares and equipment	0.425	0.475
TOTAL	$210.000	$267.900

BREAKTHROUGH

Martin's RACEP, a random access, discrete address system, represents a significant breakthrough in the field of military communications.

It is an advanced combination of radio transmitter-receiver and direct dial telephone, with advantages of both and the drawbacks of neither.

It uses no wires, needs no switchboard.

It can transmit voice, data, facsimile. Handle both individual and conference calls. It is difficult to jam.

It has a command override system that can put a commander in touch with all units immediately.

It is now being field tested by the Air Force.

Available as a vehicular unit or lightweight Manpack.

Martin pioneered this new communication system which breaks the "voice" into separate pulses which can only be reassembled by another RACEP receiver.

Martin is presently embarked on a program to extend range and flexibility of this system and to give it even broader spectrums of military effectiveness.

Martin is bringing to bear on this project the same systems management capability that developed and brought to operational readiness such systems as Pershing, Bullpup, Missile Master, BIRDiE and the Titan family.

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At Martin, Systems Management means the best possible product in the shortest possible time at the lowest possible cost

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Technical Countdown

ASTRONAUTICS

Martian Canals Explained As Sand Dunes

Following up the idea that Martian canals are sand dunes, Frank Gifford of the U.S. Weather Bureau, Oak Ridge, Tenn., calculates that the difference between terrestrial and Martian conditions would make dunes there about seven times as long as those found in the Libyan and South Arabian deserts. This means dunes 2,500 to 3,000 mi. long—about the length observed. If the canals are dunes, their size would indicate a surface pressure of about 30 millibars, which is close to the 25 millibars recently calculated by Jet Propulsion Laboratory scientists from spectrographic measurements. Martian gravity and air density lead to a requirement for wind speeds five to 10 times as high as those on Earth, if dunes are to form. These have been observed in Martian dust storms. The pattern of the canals might be interpreted in terms of prevailing winds that blow in different directions during the seasons. A difficulty in the dune theory is that 400-mi. dunes photographed from an Earth satellite look lighter than the desert around them. Martian canals look darker.

Oceanography by Satellite

Studying the oceans by means of satellite observations has been recommended by an Iron Curtain scientist who has devised a way to measure waves with the help of light reflected from the rough surfaces of the sea. A properly instrumented satellite could "map the entire surface of the oceans during periods of solar and lunar light and make determinations of wavelength quite simple," claims Soviet Academician V.V. Shuleykin. He says a special light filter will enable a satellite to expand its usefulness to mapping the color and brightness of the world's oceans.

ELECTRONICS

Electric Engine Passes Record Test

An experimental hot-electron propulsion system has recently completed a record 1,000-hr. test period at RCA's David Sarnoff Research Center without component or performance degradation. Repeated start-stop operation was employed during the testing. Developed by Dr. Hans Hendel, the RCA system employs cyclotron resonance to accelerate only electrons directly from a mercury plasma. At a power output of 100 watts, a specific impulse of 1,000 sceonds was achieved with a 30% efficiency (kinetic beam power/total RF power absorbed). Pump frequency was 2.4 gc. Plasma exhaust rate was 10^6 cm./sec.

Antenna Flight Simulator Cuts Costs

An inexpensive method for accurately testing missile guidance antennas with a scale model instead of a live firing has been devised by a 26-year-old soldier-engineer, Sp-4 Collins Smith, assigned to the Army Missile Command. His equipment permits one man to put a missile model through a simulated flight path from liftoff to impact while gathering antenna performance data. Smith uses a missile model with a subscale antenna model suspended inside a transparent globe. Drive wheels controlled by a computer rotate the globe to simulate an actual missile trajectory. The system gives a smooth, continuous curve, and an attenuator duplicates the effect of decreased signal strength experienced as a missile moves away from the launch tracking station.

Versatile Navaid Receiver/Converter Revealed

LORTAN, a Long Range and Tactical Navigation system developed for use with any hyperbolic position-finding system, can be adapted readily for sea, air or ground operation, developers claim. Built by Lear Siegler, Inc.'s Instrument Div. at Grand Rapids, Mich., the receiver/converter can provide either pictorial or numerical readout of latitude and longitude. The 21-lb. system reportedly can be used with LORAN, OMEGA and DECCA radio navaids to provide accurate positional data without time delay. Displays can be continuous, LSI disclosed.

ELDO To Use CDC 3200 Computer

Decision has been made to use a Control Data Corp. model 3200 real-time computer for guidance work on the ELDO satellite booster. The American-made equipment will be bought off the shelf by Bell Telephone Manufacturing Co. of Belgium with slight modifications to fit the ELDO mission. CDC 3200 has an 8,000-word memory at 24 bits per word, and will be used to compare actual with planned vehicle trajectories every 100 milliseconds.

PROPULSION

Largest Gimbaled Nozzle Tested

A modified *Minuteman* first stage was used to test a prototype gimbaling nozzle half the size of that needed for the 156-in. solid rocket by Thiokol Chemical Corp.'s Wasatch Div. It was four times the size of any gimbaled nozzle fabricated or tested to date. A second nozzle will be tested on a 120-in. solid motor by Thiokol later this year. The nozzles are a crucial segment of the large solid feasibility program. The nozzle was actuated throughout the 70-second firing, and exhaust gases exceeded 5,500° F. The nozzle was designed by Thiokol, Arde-Portland Div. of E. W. Bliss Co. and H. I. Thompson Fiber Glass Co. and was fabricated by the Portland Copper and Tank Works, a Bliss subsidiary.

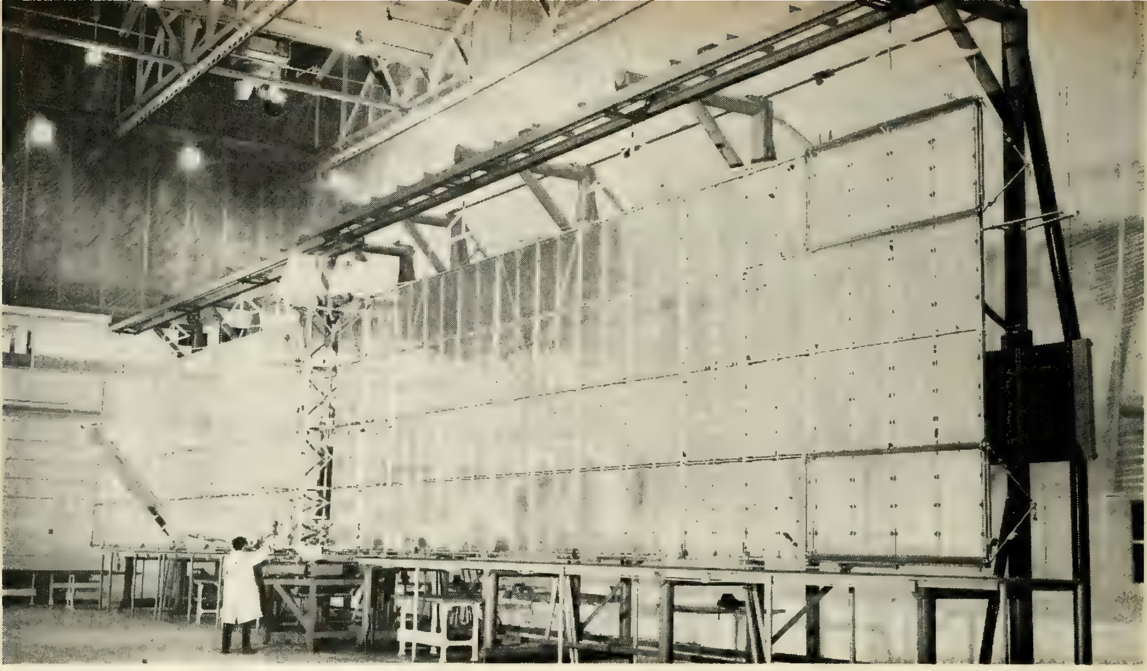
Advanced Nozzle Concept Tested

A gimbaled integral nozzle (GIN) was successfully tested on the Lockheed "Char" motor last December by experts at the Air Force Rocket Propulsion Lab, designers of the exhaust system. Partially submerged in the aft section of the rocket case, the flanges and actuating components were shielded from the exhaust gases by the case itself. The concept will lead to a gimbaling system requiring less operating power than present operational swivel-type nozzles. A heavy, high-temperature-resistant silicone grease was used to lubricate the ball-and-socket gimbaling system.

SPACE MEDICINE

The Worm Has Turned—to Research

The Planaria, a flat, arrow-shaped, inch-long worm is being studied by researchers in the Life Sciences Dept. of North American Aviation's Space and Information Systems Division to help understand human healing functions and rates under conditions of weightlessness. The unusual worm has been found capable of continued regeneration when exposed to all the extremes of temperature, vibration and shock expected in space. Also, when cut into any number of pieces in any direction, each piece regenerates within 10 days.



space systems

Meteoroid Satellite Passes Crucial Tests on Way to Mid-64 Flight

by Charles D. LaFond

THE *METEOROID DETECTION Satellite* being built by Fairchild Stratos Corp. for Marshall Space Flight Center has passed two critical test points successfully.

Scheduled for launch into Earth-orbit in mid-1964 aboard a *Saturn I* booster vehicle, the 3,400-lb. NASA satellite will employ two 50 x 15-ft. extendable detector wings. The unusual size of the spacecraft presents structural problems not encountered previously with U.S. vehicles.

After completion of breadboards of the spacecraft electronics, Fairchild Stratos engineers produced an engineering test model to integrate the communications, data, sensing and housekeeping systems and ground checkout equipment in essentially their final circuit configurations. Results of the mating of the engineering test model components were highly satisfactory, MSFC officials said, with every indication that the system is capable of returning useful data from orbit.

The system's solar electrical power supply presently is undergoing separate tests satisfactorily, and the development program for capacitor detectors apparently will result in a system capable of performing all of its functions.

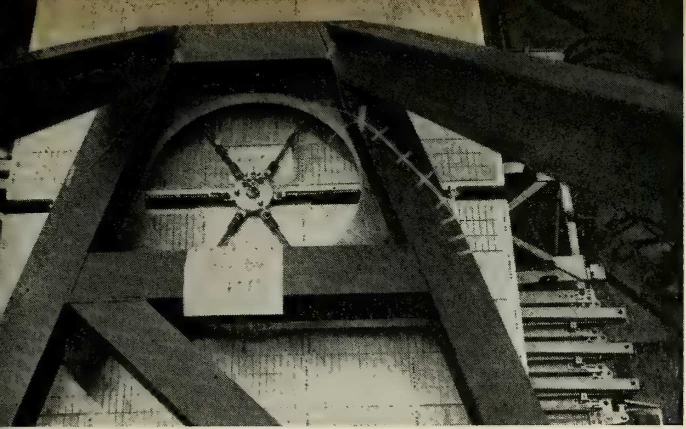
An equally vital and even more impressive phase of the program to date was the recent completion of a comprehensive vibration test and analysis on a full-scale structural and mechanical test version (dynamic test model) of the huge spacecraft. Tests were conducted at the General Electric Co.'s Missile & Space Div. at Valley Forge near Philadelphia, Pa.

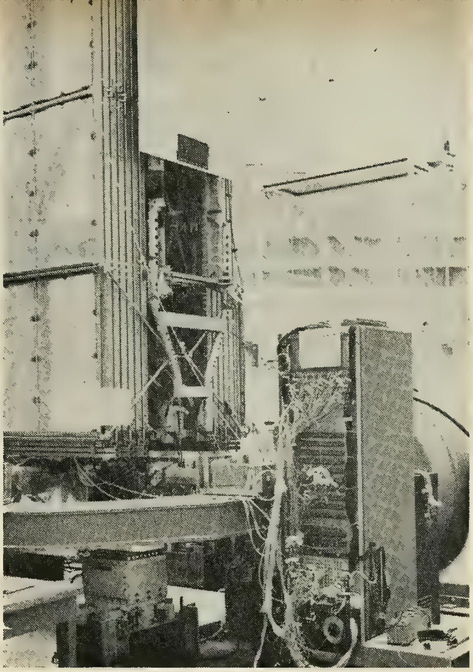
• **Unusual complexity**—In addition to having the electronic complexity of other unmanned spacecraft, the *Meteoroid Detection Satellite (MDS)* is mechanically and structurally complex because of the requirement for extending its detector panels in a 15 x 100-ft. wing once the satellite is in orbit. The resulting structure is characterized by complex load paths and interactions. Further, because of the size of the satellite, even with the wing panels folded, it cannot be isolated from the vibration environment.

Vibration levels to which the model was subjected were determined by those expected during the boost phase of the *Saturn* vehicle. At this time, the structure is folded with the wings and solar panels under restraint and the top of the spacecraft fastened to the *Apollo* boilerplate service module.

Fabrication of the prototype electronic system is well underway for the *MDS*, and data obtained during the vibration tests is in final evaluation prior to assembly of the prototype mechanical and structural systems.

Prior to vibration testing, the "wings" (meteoroid detector panels duplicating those panels planned for the flight capsule) were deployed to their full 100-ft. span, and deployment of the solar panels was tested, both successfully. The module was then subjected to vibration in all three planes, including resonant swell at points detected during low and high level sweeps; after vibration, the spacecraft was returned to the deployment





LEFT: Meteoroid Detection Satellite in deployment fixture. The 3,400-lb. spacecraft is scheduled for launch in mid-1964 aboard a Saturn I vehicle. ABOVE: Attachment of vibration support fixture (top ring) to MDS, simulating restraint afforded by tie-at-the-top (attachment to Apollo boilerplate service module). Explosive release system is at center of ring. RIGHT: MDS installed on vibration fixture with accelerometer and strain gage switching unit. Testing was performed by General Electric's Valley Forge test facility.

fixture and again deployed. All phases of the test were satisfactory, officials disclosed.

• **Three-month test**—The entire test operation, from the beginning of preliminary work on setting up test fixtures by General Electric personnel to the return of the test model to the Fairchild Stratos plant at Hagerstown, Md., took just three months.

The initial test was a static load test of the center structure to limit load levels. Upon completion of static testing, the center section was removed from the static test fixture and installed in a deployment jig. The detector panels and frames, solar panels, electronic canister mass simulator, and panel drive mechanisms were integrated with the center section to form a complete dynamic model of the spacecraft.

By mid-October, the completed test model had been given a test deployment, was packaged and shipped to Valley Forge, where it was installed in a deployment jig and opened so that all detector panels could be removed for replacement of mounts (with which last minute trouble had developed).

At the end of October, an instrumented deployment test was run, and by Nov. 12, the first-axis vibration test was begun. With a three-week delay in late November and December while the vibration equipment was used for another previously scheduled test, *MDS* model testing was completed on Dec. 20. The model was shipped back to the Fairchild Stratos plant on Jan. 4.

During the time it was at the test facility, design improvements were made in the forward solar panel support system, wing panel restraint system turnbuckles, and side solar panel deployment starter springs. These improvements were incorporated into the design in time to be tested and proved out.

• **Test results**—Vibration levels experienced in most parts of the test model were lower than predicted. The electronic canister experienced higher than predicted vibration levels, and a design was initiated for a straightforward vibration isolation system so that levels experienced by prototype and flight canisters will be lowered.

For the dynamic test model, a manual deployment motor and gear box were used. Additional deployment tests will be conducted to evaluate the performance of the system with the operational motor and gearbox. A system is being designed for additional tests of the solar panel deployment, with the panel mounted in a manner to remove the effect of gravity. Fairchild Stratos engineers indicated they were not satisfied that the wing restraint system has been satisfactorily demonstrated, and an improved version will be tested on the dynamic test model before installation on the prototype.

MDS Test Plan

1. Previbration deployment test.
2. Low-level sweep in all three axes at (input levels):
   - 5 to 9 cps at 0.2 g, 0 to peak.
   - 9 to 2,000 cps at 0.5 g, 0 to peak.
3. High-level sweep in all three axes at (input levels):
   - 5 to 9 at 0.5 in D.A. displacement.
   - 9 to 42 cps at 2.0 g, 0 to peak.
   - 42 to 64 cps at 0.022 in. D.A. displacement.
   - 64 to 2,000 cps at 4.6 g, 0 to peak.
4. Resonant 5-minute sine tests at critical frequencies at half the high-level sweep values.
5. Post-vibration deployment test.

• **Instrumentation**—To provide completely reliable, significant data, the dynamic test model of the spacecraft was instrumented with 240 strain-gage outputs and 130 accelerometers. Low-level sine sweeps were conducted in three axes and the data were reduced to determine the 22 accelerometers and 36 strain gage outputs which would be monitored continuously during the high-level sine sweep.

As a side benefit from the operation, Fairchild Stratos personnel were able to evaluate handling procedures, since shipping containers, slings and jigs used were identical with those planned for use with the flight and prototype spacecraft. Also, the company designed and delivered test fixtures that allowed mounting the model in a manner simulating the *Saturn* mounting.

General Electric supplied the vibration test equipment, the instrumentation and recording equipment, the test documentation and test personnel. ■

At Northrop Nortronics we've learned that to think big is to build small. As aerospace technology probes farther out, the demand is for ever-greater capability compressed into ever-decreasing space.

Our NDC-1000 computer, now in the final stages of development, illustrates the point. It occupies less than 1 cubic foot, weighs a mere 35 pounds. Yet packed inside is the equivalent of nearly one million components.

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general purpose computer with the same capabilities would fill this entire room.

'hat is our forte, and has been since 1947. That year we
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l uncharted field. To solve it, we invented the digital differ-
ial analyzer and then combined that with a magnetic-drum
mory for a genuine breakthrough.

'or the SM-62 missile guidance system, we designed the
st solid-state airborne digital computer. A dramatic
iievement in missilery, this system had to operate continu-
sly for as long as 11 hours, with no control or correction
m the ground.

To integrate still another system, GAM-87, we came up with a solid-state unit, 6 cubic feet in size, which was 4 computers in one: a general purpose computer, two digital differential analyzers, and a star tracker computer. It interfaced, reliably, with 11 other subsystems.

This is the kind of imaginative thinking and inventiveness you can call on when you put a systems integration problem up to Northrop Nortronics.

NORTHROP NORTRONICS

General Electric Embarks on Testing Nuclear Space Power System Dynami

Technology termed 'almost adequate' for present turbogenerator concepts; working fluids narrowed to a few alkali metals, but handling them is still problematical

CINCINNATI—The first tentative steps toward flight-weight, high-powered nuclear turbogenerator systems are being taken at General Electric's Space Power and Propulsion Section here.

Under the direction of M. A. Zipkin, manager of the Space Power and Propulsion Div., a complex of materials and component testing facilities have been built and are in operation. "The cycle is firm," says Zipkin, "the working fluid choices are narrowed to only a few alkali metals, the construction materials are in sight, the temperature is attainable and the configuration workable."

Development of specific operating components such as the turbine, seals, bearings, pump and boiler is only beginning, but the basic technology is almost adequate for present space power systems concepts.

"There should be no basis for complacency," says Zipkin, however, "because much more detailed data are needed to support the component test programs throughout their complete development cycle."

• **Based on Rankine cycle**—General Electric is working toward a large space power generating system based on the Rankine cycle. One GE version of the cycle has two separate liquid metal flow loops—one transferring heat from the nuclear source to the boiler, and the other taking heat from the boiler and vaporizing the liquid metal working fluid, which is then expanded through a turbine and condensed in a radiator.

The Rankine cycle, say GE experts, approaches the thermal efficiency of the Carnot cycle because most of the heat addition and rejection is done at constant temperature. High thermal efficiency and constant heat rejection temperature result in minimum radiator size.

The crucial aspect of any such power system is the containing, handling and pumping of liquid metals at high temperatures. GE has had three major two-phase alkali metal loops operating over a year at the Evendale plant (M/R, May 28, 1962, p. 28). These have been supplying compatibility data and other information basic to the design of a reliable and long-lived space power system.

The loop systems include a 300-kw facility, a 100-kw test unit and a 50-kw installation. The three units provide a combined operating temperature range from 800° to 2,200° F with liquid metals such as sodium and potassium.

In addition, there are countless tests being conducted on materials in small capsules held at liquid metal temperatures in controlled environments. A significant contribution has been made in the field by the firm. As little as 18 months ago practically no such design data existed.

The latest sections of the multi-million-dollar integrated space power laboratory are now in operation with the completion of the dynamic component test facility.

• **Component Test Facility**—The 3,000-kw Component Test Facility will be used to obtain performance and endurance data on developmental components for space power plants operating on alkali metals in the Rankine cycle.

The basic components that can be tested in the facility include heat exchangers, boilers, turbines, pumps, condensers and radiators.

The complex consists of a gas-fired boiler producing alkali metal vapors, an air-cooled condenser to liquify this vapor and an electromagnetic pump to return the liquid to the boiler.

The boiler is rated at 3,000 kw as latent heat in the metal vapor. The condenser is designed for a heat rejection rate of 3,000 kw at the minimum vapor temperature of 1,200°F. The pump is rated for 42 gpm at a 150 psi pressure rise. Boiler flow is about 3 lbs./sec.

The first boiler tube bundle of 316 stainless steel is capable of 1,600°F—and, with a modified boiler tube bundle the upper limit reaches 1,850°F. The rest of the system is designed to complement the upper temperature regime.

A zirconium getter attached to the boiler and parallel to the natural recirculation takes up any impurities present in the liquid metal and carried over into the vapor state.

Controls are manual wherever practical in order to maintain maximum flexibility in the facility. Safety controls are both manual and automatic. In most cases, operator discretion is imposed on the safety action. Basic indicators include smoke detection, over-temperature, over-pressure and over-speed when rotating machinery is under test.

• **Turbine development**—The turbine is the key to a nuclear turbogenerator system. "Just running this component in the high temperature metal vapor system is a major accomplishment," says Zipkin.

Once the turbine is functioning in the test system, the next step is to move into performance testing, This phase will prove out the design approach, and GE has taken the position that space power system turbines are directly related to both nuclear, steam and high-temperature-gas turbines.

Components

by John F. Judge

The problems of wet vapor operation in all turbine stages are present as well as the additional complexities of high temperature creep, fatigue and stress rupture. Initial testing will be performed only on the third and fourth stages of a five-stage turbine design.

The first stages encounter the hot, dry working medium and this medium gets progressively cooler and wetter as it moves through the turbine stages. The stages under initial test face the greatest danger of erosion because of the moisture and their blade velocities.

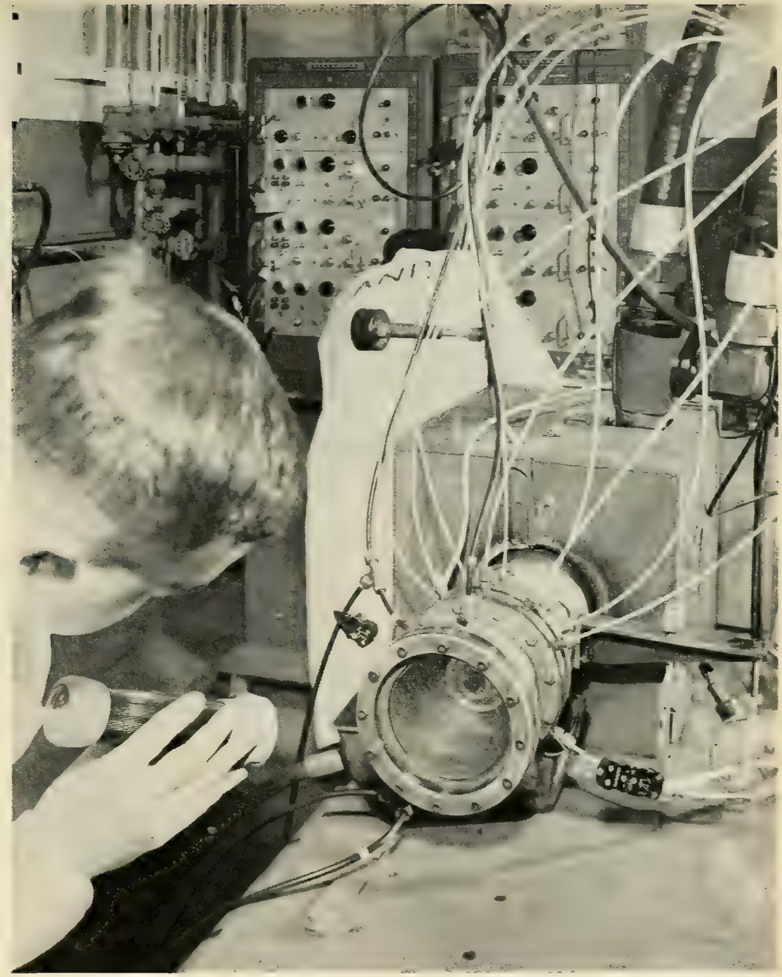
In addition, these stages represent the turbine region where the fluid temperatures have decreased to a point amenable to use of high-nickel superalloys instead of the refractory metals necessary in the inlet stages.

• **3-phase test program**—The detailed turbine test program is divided into three major phases. The first segment will involve determining the aerothermodynamic characteristics of the turbine in a series of performance tests.

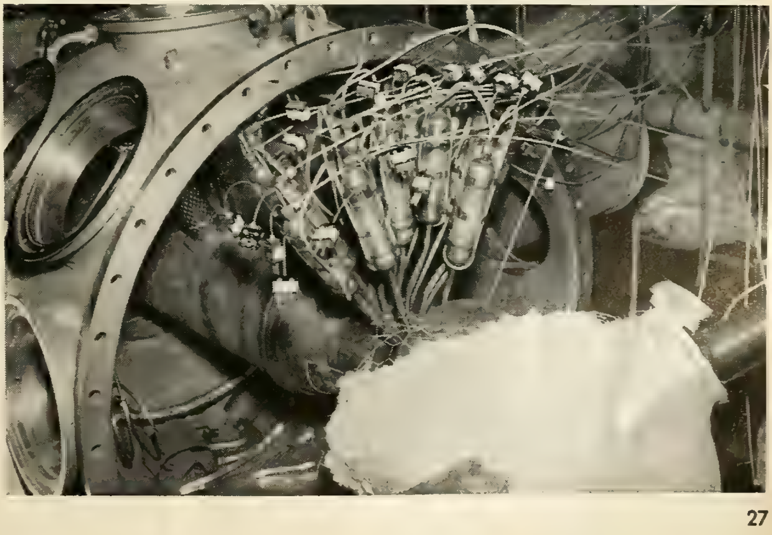
Data will be gathered at various turbine inlet temperatures, vapor qualities, and rotational speeds. Temperatures will vary from 1,400° to 1,600°F, speeds from 15,000 to 20,000 rpm and vapor qualities from 85% to 50°F superheat.

The second phase covers design-point endurance and should show the capability of the turbine to operate for the prolonged periods required by space systems. This demonstration will involve a 1,000-hr. run at 19,200 rpm at an inlet temperature of 1,550°F and a vapor quality of 90%.

A similar endurance test is planned for the third phase. Here the aim is to determine accuracy of the predictions of blade erosion onset.



ABOVE: Rotating disc squeeze seal test rig in operation. Device is used to evaluate and perfect dynamic seal designs for turbine tests. BELOW: Performance tests run on 3,000-kw facility involved these pressure tapes on the convergent-divergent nozzle used to simulate turbine pressure drop. The small cans on each line are "de-misters" that prevent potassium from blocking line.



Again, the run will last 1,000 hours, but at 23,000 rpm with a vapor quality of 85% at the inlet. Different turbine bucket materials will be evaluated.

- **Instrumentation**—Both static and total pressure taps have been built into the turbine hardware together with thermocouples. The instrumentation was welded and brazed into the turbine parts and casing themselves, because the alkali metal system has to be completely sealed.

GE experts were also faced with the problem of separating the loop potassium from the bearing lube oil in the test rig. A liquid potassium hydrodynamic seal and an argon-purged labyrinth seal effectively prevent mixing between the potassium vapor and the forward bearing sump.

- **Lubrication problems**—Bearing and sealing problems are practically a separate field of effort in themselves at GE. Liquid-metal-lubricated bearings bear little resemblance to those lubricated by more conventional means, because the kinematic viscosity of the liquid metals is around 1/1000 that of normal friction alleviators.

An additional complexity is added by the emphasis on minimum system weight, which results in higher rotational speeds through component compaction. This creates entirely new problem areas in the operation of stable bearings.

Zipkin says stable bearing operation is as much of a problem as finding adequate materials. But one research advantage is that the dynamic effects and stability of liquid-metal-lubricated bearings can be simulated in fluids of similar viscosity and density.

Zipkin lists three different sources of high-speed-bearing shaft instabilities:

—Half-frequency whirl—an instability of the fluid film on the bearing characterized by a whirl of the journal centers at a speed of approximately half the shaft rotational speed.

—Synchronous whirl—a forced vibration of the journal caused by a rotating load such as an unbalance. Its frequency is equal to the rotational speed of the shaft and the magnitude depends on the amount of unbalance, shaft mass and deflection characteristics, lubricating film stiffness and damping.

—Resonant whip—a shaft instability that has a frequency corresponding to the first system critical, even though the shaft is rotating at a substantially different speed. Such an instability occurs at speeds exceeding twice the first system critical speed.

GE engineers have developed a bearing test rig using water as the lubricant. The complex consists of a test section containing the test bearings and test shafts, the means for bearing load applications, the instrumentation for measuring the motions of shafts and bearings, absolute and relative to each other.

The lubricant flow can be controlled to individual bearings. The lubricant can be cooled or heated, providing a wide range of viscosities. The minute non-rotary motions of the shafts and bearings are measured through 12 capacitance gauges—each rigidly mounted and air-blasted at the tips to eliminate lubricant interference.

Nine selected bearing designs now undergoing tests in various configurations include three-lobe types, orthogonally displaced bearings and pivoted-pad bearings.

A two-phase experimental program will be used to evaluate the selected bearing configurations. The whirl resistance of the different configurations will be determined in the first segment of tests. These whirl characteristics will be determined over a range of shaft speeds, loads, lubricants, pressures and temperatures, clearances, and bearing length-to-diameter ratios.

The second group of experiments will involve detailed investigations of those configurations showing the most promise for stable operation.

Water will be the lubricant used since this simplifies the study and permits testing at room temperature. Bearing performance measurements can be obtained much more accurately in water than in liquid metals. The significant characteristics of potassium and sodium bearings such as Sommerfield and Taylor numbers can be closely simulated in water if larger bearing clearances are used.

- **Seals also problem**—While a wide variety of seals have been successfully used for many years in different types of turbines and some have contained even liquid metals for significant periods, seals still remain a troublesome element and the cause of many failures.

A new goal has been added in space-bound seal applications—zero leakage. This covers not only the working fluid but any buffer fluid used. This ideal can be closely approached, but not absolutely attained.

The GE program has concentrated on dynamic seals. The prime aim is to prevent significant leakage. The development approach moves through three main steps:

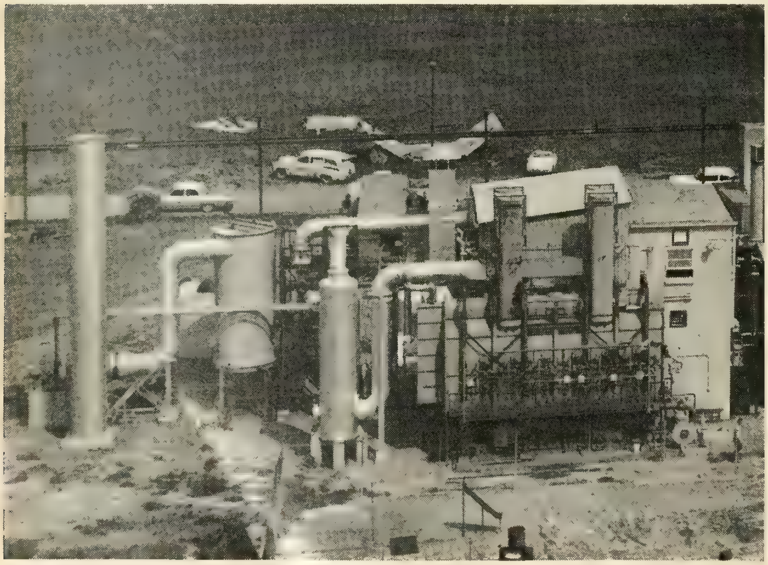
—Providing a pressure dam through which a transition from the high pressure of the working fluid, liquid or gas, to the lowest pressure level possible may be accomplished.

—Generating a distinct separation between liquid and vapor phases of the working fluid and preventing direct leakage of liquid to the space vacuum.

—Minimizing vapor pressure of the working fluid in the region of the final restriction and consequently vapor leakage.

Zipkin maintains that the proper application of the above principles will result in an acceptable seal. The GE team is now working with a 36,000-rpm liquid metal test rig, although sealing principles are originally demonstrated in water. The rig has a 15-hp turbine driving a gas bearing spindle that extends into a 1,400°F liquid metal bath. The seal configuration to be tested is mounted between this and a vacuum chamber where the spindle ends. ■

COMPLETED 3,000-kw facility at General Electric houses turbine test section immediately behind gas-fired potassium vaporizer at right.



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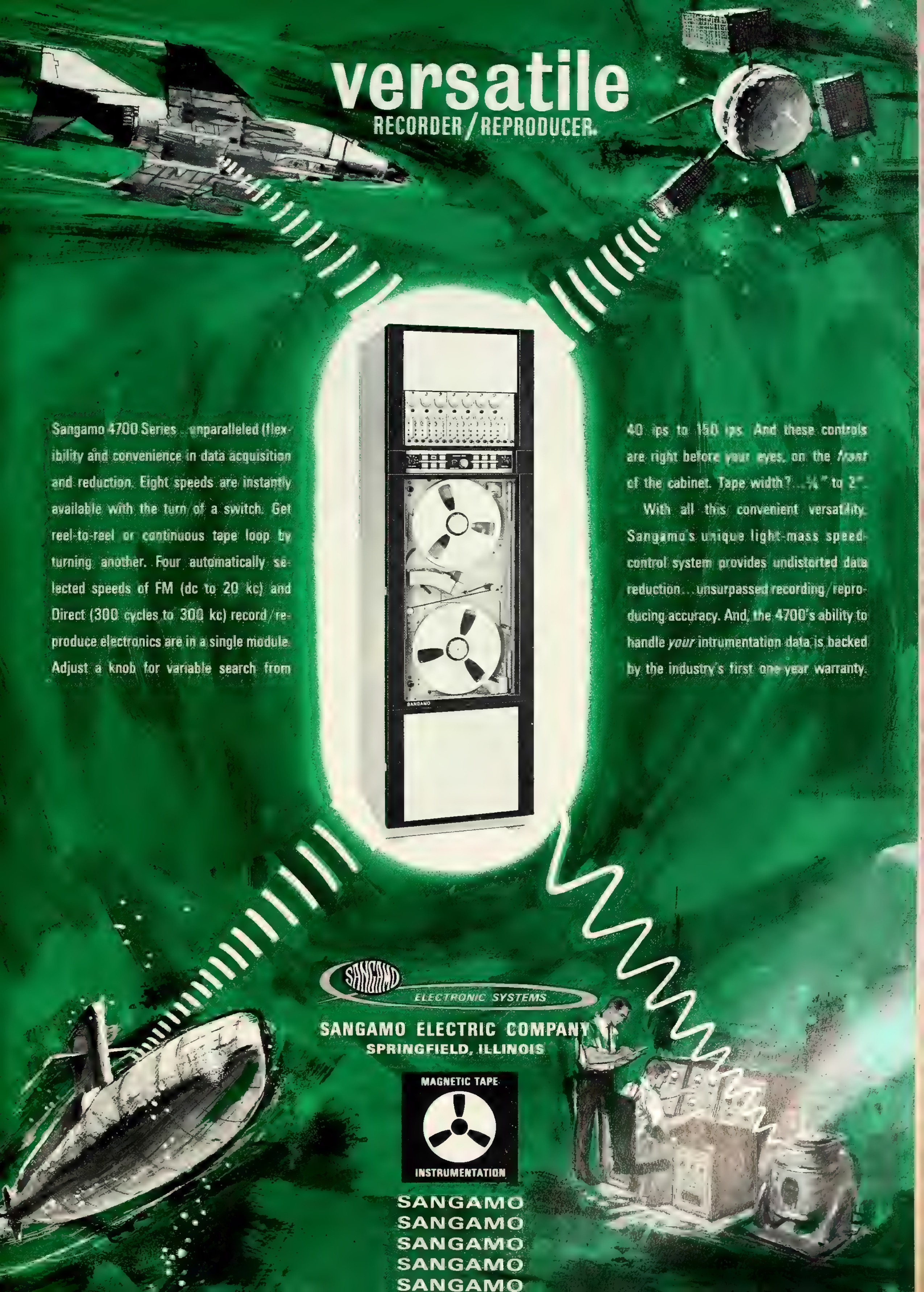

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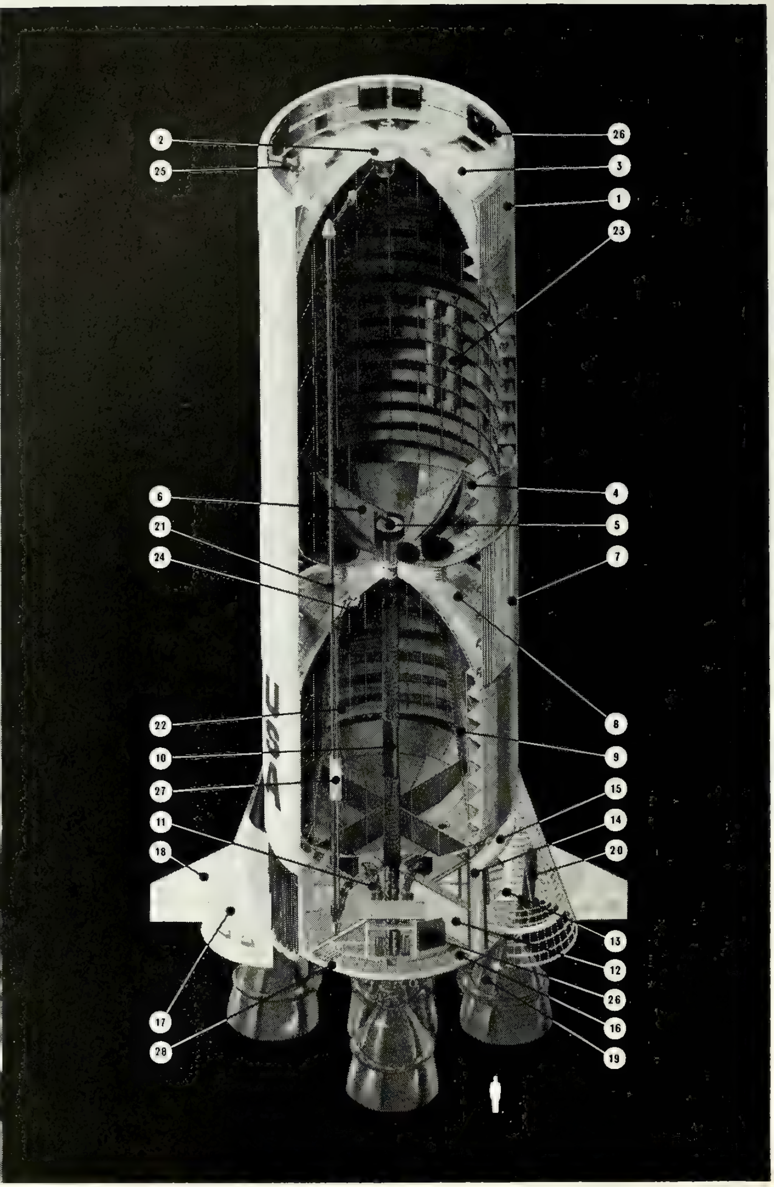

Inside the free world's largest rocket booster

Saturn V, standing tall as a 30-story building and weighing some six million pounds, will take off for space powered by an S-1C first-stage booster.

Shown in the cutaway drawing above, the S-1C will be the free world's largest rocket booster. Boeing holds the National Aeronautics and Space Administration contract to design, develop, build and support the testing of the S-1C. It will incorporate a cluster of five F-1 engines producing a total thrust of 7½-million pounds, or about 160-million horsepower.

Boeing scientists and engineers, backed by unsurpassed research facilities, are at work on a wide variety of missile, rocketry and space-vehicle programs. They are scoring advances in such areas as life support systems, guidance, electronic systems, vehicle design, lunar base requirements.

The breadth and depth of Boeing's technological capabilities, plus its outstanding record of successful management of advanced, complex systems, equip Boeing to make significant contributions to the nation's progress in space — from launch systems to orbiting laboratories, planetary landing programs and space rendezvous and logistics missions.

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(1) Forward skirt structure (2) GOX distributor (3) Oxidizer tank (4) Anti-slosh baffles (5) Anti-vortex device (6) Cruciform baffle (7) Intertank structure (8) Fuel tank (9) Suction line tunnels (10) Oxidizer suction lines (11) Fuel suction lines (12) Center engine support (13) Thrust column (14) Hold down post (15) Upper thrust ring (16) Lower thrust ring (17) Engine fairing (18) Fin (19) F-1 engine (20) Retro rockets (21) GOX line (22) Helium line (23) Helium bottles (24) Helium distributor (25) Oxidizer vent line (26) Instrumentation panels (27) Cable tunnel (28) Umbilical panel

Accuracy of Canoga Radar Tracking System Is Six Feet in 30,000 Miles

by Rex Pay

LOS ANGELES.—An accuracy of six feet in 30,000 miles is claimed for Electronic Digital Tracking and Ranging (EDITAR) equipment—intended for radar tracking of space vehicles and reentry bodies moving at speeds up to 60,000 feet per second.

This system has been supplied by Canoga Electronics Corp., Chattsworth, Calif., for use on a tracking ship with a high-power C-band radar for Air Force re-entry studies.

Describing the equipment at the 1964 National Winter Convention on Military Electronics, Douglas Epps, Frank P. Kaatz, and J. H. Werlin said that targets with acceleration of 4,500 ft./sec.^{2} could be successfully tracked.

The system maintains track over several pulse-repetition periods through interference between the transmitted and return pulse, and continues to track returns with signal-to-noise ratios as low as −3.5 db. Skin and beacon returns can be tracked simultaneously. Range relative to the primary target or secondary targets such as decoys, booster stages, and re-entry debris can also be measured.

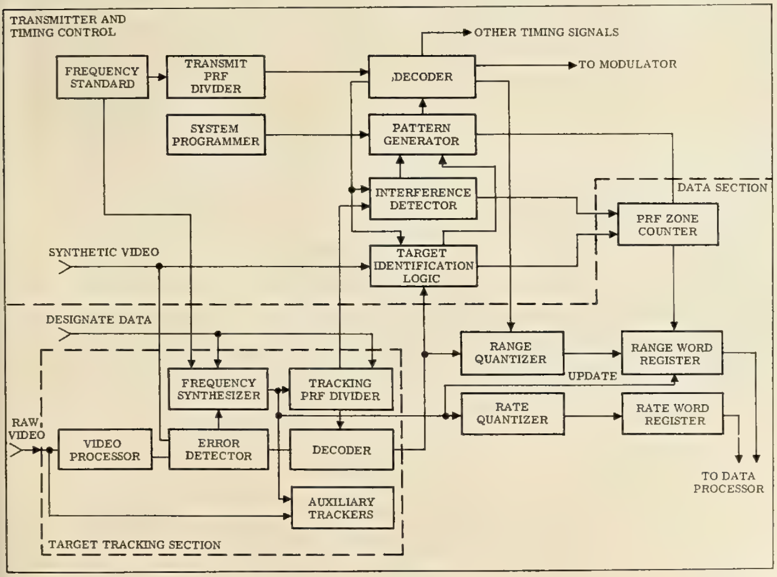
The system can acquire and identify its own target automatically among returns generated by other radars looking at the same target and operating at the same pulse repetition frequency.

EDITAR was produced under a subcontract worth about $1 million and is currently being evaluated along with the rest of the tracking ship system. Unofficial reports indicate that it is working well.

Canoga project engineer for EDITAR, J. H. Werlin, believes, however, that Canoga is unlikely to build another system of this sort. Instead, a general-purpose computer would be used to carry out the function of the EDITAR equipment, as well as radar data processing.

- **System's uniqueness**—The distinctive feature of EDITAR is its use of an all-electronic digital tracking loop. Mechanical tracking loops can track out to 10 million yards, but cannot meet the EDITAR requirements of tracking at speeds of 60,000 fps out to ranges of 67-million yards.

DIAGRAM OF Canoga's Electronic Digital Tracking and Ranging system.


TRANSMITTER AND TIMING CONTROL
OTHER TIMING SIGNALS
FREQUENCY STANDARD
TRANSMIT PRF DIVIDER
DECODER
TO MODULATOR
SYSTEM PROGRAMMER
PATTERN GENERATOR
DATA SECTION
INTERFERENCE DETECTOR
PRF ZONE COUNTER
SYNTHETIC VIDEO
TARGET IDENTIFICATION LOGIC
DESIGNATE DATA
RANGE QUANTIZER
RANGE WORD REGISTER
UPDATE
FREQUENCY SYNTHESIZER
TRACKING PRF DIVIDER
RATE QUANTIZER
RATE WORD REGISTER
RAW VIDEO
VIDEO PROCESSOR
ERROR DETECTOR
DECODER
TO DATA PROCESSOR
AUXILIARY TRACKERS
TARGET TRACKING SECTION

Because most new precision tracking radars now include a computer to perform on-line data processing, coordinate conversion, target acquisition and data correction, computing capacity is available for carrying out the functions of the EDITAR tracking section and fine range quantizer. If this is made use of and backed up with a highly stable frequency standard, the radar gains the capability of tracking high-performance targets.

Canoga is working on variations of of the EDITAR system for use in retrofitting existing radars.

With a digital servo loop for tracking, a computer-equipped radar can also compute its optimum loop transfer function and modify the loop by switching components in or out of circuit as tracking conditions demand. Such a radar functions as an automatic real-time adaptive system, dispensing with the need for an operator and communicating directly with a central computer in a radar net.

A Univac 1218 or smaller real-time digital computer could replace the present EDITAR. The actual size of the computer needed would depend on the functions required, in addition to digital ranging.

Canoga would buy the computer and manufacture the components for tying the computer into the radar. The cost of the components would roughly equal that of the computer.

- **Range capabilities**—EDITAR was designed for a range of 32,000 miles at a pulse repetition frequency of 160 pulses per second. For more agile targets, the prf—and hence the data rate—could be quadrupled. The range would then be 10,000 miles, still covering the space area of prime military interest.

Originally, the system was conceived

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Size is no object. Small titanium bottles, made by D-K Manufacturing Company, Chicago, from Wyman-Gordon Co. forgings, hold 150 cu. in. of oxygen at 3,000 psi and weigh only 3.65 pounds. On the other end of an almost unlimited scale of size is the titanium tank made from sheet metal by Beech Aircraft. It measures 8 x 24 ft., holds 7,000 gallons of liquid hydrogen, yet weighs only 473 pounds.

TITAN III oxidizer and fuel tanks. Ti-6Al-4V is used for upper-stage nitrogen tetroxide tank (46 x 174 in.) and the unsymmetrical dimethylhydrazine tank (63 x 154 in.). Shown above is one of the titanium roll forged cylinder sections and stiffener rings produced by Ladish Co. for Martin Company for use in tank construction. Final machining and welding are done *after* heat treatment, eliminating distortions and production difficulties inherent in many heat-treatable metals.

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Compatible with fuels and gases. Titanium shows outstanding resistance to liquid and solid fuels and oxidizers in use today or planned for the future. Its impermeability to hydrogen and resistance to sea-water and atmospheric corrosion mean thorough reliability and indefinite storage life.

Alloy availability. A variety of titanium alloys are available for tankage construction — two of them in Titanium Metals Corporation of America's ELI (extra low interstitials) compositions, developed specifically for liquid hydrogen service. Only TMCA can supply all titanium alloy grades in any commercial product or size required.

Meets fabricability requirements. Titanium is at home in the two important approaches to tank construction: the use of machined roll forgings and the application of thin-gage sheet. Titanium is fabricated on conventional equipment. Add these facts together, and you'll find that titanium is your single, most efficient material of construction for tankage, regardless of size.

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EMINI Titanium pressure vessels. Vessels used throughout emini spacecraft are made from titanium to minimize dead-eight which must be lifted off the ground. Shown here are tita-um hemispheres hydroformed by California Hydroforming ompany, Inc., El Monte, California. **APOLLO liquid hydrogen ottles.** Pressure vessels are produced from titanium alloy grade i-5Al-2.5Sn ELI to provide exceptional toughness to cryogenic mperatures. A typical bottle weighs only 12.9 pounds, has a all thickness of 0.031 in.; at the weld girth, 0.044 in.

MINUTEMAN titanium second stage. Cylindrical sections possess great stiffness at minimum weight. Minuteman cases consist of roll forged cylindrical sections welded together. Titanium welds are as strong or stronger than parent metal, are less sensitive than steel to weld porosity and need no pre- or post-heating. **Titanium water bottle costs less than fiberglass,** weighs 17 pounds less than steel or fiberglass and is used on Boeing 727 as the most efficient way to save weight. Shown also in photo is titanium tubing for cabin heat system.

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as a means of adapting pulse radar to lunar ranges. But the trend for such distances is away from pulse radar to CW doppler techniques.

EDITAR supplies pulse-position encoding to the radar transmitter. This enables tracking through interference between transmitted and received pulses, resolves range ambiguity when a signal is returned after several pulse repetition periods, and identifies the target.

In system tests, the tracking loop locked onto a target moving at 66,000 fps within 500 ms of its entry into the receiver's wide tracking gate (2,560 yards). Within a total elapsed time of one second, tracking error was reduced to 10 yards.

A target moving at 60,000 fps was given an acceleration of 150 G for 0.1 sec. At a signal-to-noise ratio of 0 db, the resulting transient tracking error of 30 yards dropped to five yards within two seconds and to zero within three seconds. At +12 db signal-to-noise ratio, maximum transient error was four yards.

Basic timing source for the whole system is a 5.1224375-mc crystal with a stability better than five parts in 10^{10} per 24 hr., and an accuracy of one part in 10^{10}. This operating frequency has a period of 32 radar yards.

- **Digital tracking system**—In the design philosophy of EDITAR, the tracking and range-measuring functions are separated. So the design of the tracking loop was optimized for a single function—that of putting a gate around a target return pulse and keeping it there. Target range is inferred from the position of the gate.

The system is capable of lead-lag edge or centroid tracking, and switches automatically from edge to centroid tracking below a predetermined signal-to-noise ratio.

The EDITAR tracking loop works like the classical mechanical tracking loop that contains a range-error detector, an error amplifier that drives a servo motor mechanically coupled to a phase shifter, an accurate frequency source for the range scale factor, and a generator giving range early and late gates for the error detector. In the EDITAR system, however, the servo motor and phase shifter are replaced by an electronic frequency synthesizer and a digital frequency divider.

As the basic loop has no inertia caused by mechanical components, a variable bandwidth control is put into the loop to ensure stable tracking. This control is adjustd to adapt the response characteristics of the system to the target quality or noise conditions.

Type III servo response is obtained by including two integrators that hold the synthesizer output frequency to a value that will keep the track gates moving at the velocity and acceleration of the target.

- **Pulse position coding**—The transmitter pulse coding in the EDITAR system is a simple method whereby the transmitted pulse is either normal (on time) or shifted (advanced by —98,304 yards).

To resolve range ambiguities, the range machine causes a single transmitted pulse to be shifted. A prf zone counter then counts the number of normal pulses that is transmitted before a target return is detected in the shifted tracking gate. (The tracking loop can generate range gates for both the normal and the shifted positions).

For tracking through interference between transmitted and returned pulses, a zone that extends the shifted distance on either side of the main pulse is set up in the receiver. Entry of a return pulse into this gate recodes the transmitter pulses. The zone is made wide enough so that a target moving at maximum tracking velocity will be detected soon enough for action.

When a returned pulse enters the interference zone, a certain number of normal pulses is transmitted, followed by exactly the same number of shifted pulses. The actual number equals the pulse repetition zone number, already detected by the initial pulse shifting.

Updating of the zone number always occurs when the target crosses a 68,536 yard marker. Target reversal in the interference zone causes no problem.

The pulse position coding also provides the target identification feature of the system. Where target designation is not available, the system operates in an automatic acquisition mode, whereby the range machine starts a search of the entire tracking range. Each return is checked for compliance with the transmitter pattern, which in this mode is an alternation of normal and shifted pulses.

The system can search a 65,000-yard zone and identify its own target in the presence of up to five returns from other radars in less than two seconds.

When the target return is legitimate, the return sequence agrees with the transmitted sequence, and the tracking loop picks up incoming pulses.

- **Digital range output**—The range machine builds up a 25-bit binary coded word representing range in three steps. First the prf zone in which the target is located is measured. Range to within 32 yards is then measured by counting the pulses from the stable crystal oscillator after the appearance of the transmitter trigger up to the occurrence of the range notch. Simultaneously, a vernier system quantizes the elapsed time between the last 32-yard pulse stored in the counter and the occurrence of the range notch. ■

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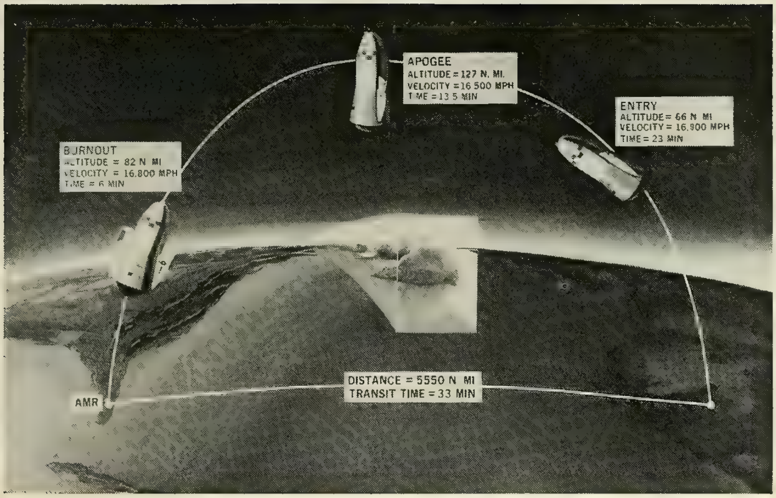

TYPICAL mission profile for ICARUS at 3-G maximum during ascent or descent.

Douglas Proposes An Intercontinental Ballistic Transport for 1,200 Troops

'ICARUS,' a modified version of vehicle concept based on reusable booster study, would use existing technology

by Willard E. Wilks

DOUGLAS AIRCRAFT CO.'s Missile & Space Systems Division is seeking military interest in a single-stage intercontinental ballistic troop transport concept that could deliver 1,200 combat-ready men or 132 tons of equipment anywhere on Earth within 45 minutes.

By coincidence, spokesmen say, the company was developing the concept last fall when Lt. Gen. Wallace M. Greene, new Marine Corps commandant revealed that the Corps was seriously studying the idea of rocketing 1,200-man battalions over intercontinental distances. Greene declared at the time that this application of space technology to conventional warfare could have a staggering impact on sea power and amphibious operations and on future national military capability as a whole.

Based on Douglas' *ROMBUS* conceptual vehicle and dubbed *ICARUS* (Inter-Continental Aerospacecraft-Range Unlimited System) the concept grew out of an in-house study into the role of the reusable booster. As outlined by Philip Bono, advance projects engineer, and George C. Goldbaum, advance program manager, such a 17,000-mph global transport could be developed with existing technology.

The Douglas study notes that while last October's "Operation Big Lift" was successful in transporting 15,700 troops and 500 tons of cargo to Europe in 235 missions, that method of troop movement would appear to be "completely impractical" under hostile conditions, being dependent upon, in addition to good weather, long landing runways and other support easily detected and destroyed.

- **Ahead of SST?**—A point made by Douglas spokesmen is that the technology for *ICARUS* is at least as far advanced as that for a supersonic transport vehicle, which also requires prepared landing strips. They also point out that the concept would be a "fallout" application of reusable boosters developed for orbital, lunar and planetary missions. Or, developed first as a troop carrier, the vehicle could be scaled down for space station resupply.

ICARUS would be a modified version of the *ROMBUS* (Reusable Orbital Module-Booster and Utility Shuttle) vehicle designed for land recovery. With a pressurized, six-level troop compartment as the payload, it would be 210 ft. high and 70 ft. in diameter. A four-man crew compartment would be located in the center-body.

The vehicle would consist of this center-body surrounded by perhaps 8 disposable but recoverable liquid hydrogen tanks. It would use an isentropic plug-nozzle engine in order to survive aerodynamic heating during a stable base-first entry. Four landing legs would extend following use of the same engine to provide retro-thrust for soft-landing. Fins would be added to the center-body between hydrogen tanks to reduce entry decelerations to a maximum of 3 G's.

A one-fifth smaller configuration requiring 4 million lbs. thrust could be utilized as a commercial global transport carrying 172 passengers and 36,000 lbs. of cargo to any point on Earth in less than 45 minutes. ■

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Tactical 3-D Radar. AN/TPS-34 by Sperry—among the latest tactical air defense systems—is being delivered to the U. S. Marine Corps, and has been selected by the British Ministry of Aviation for use by the Royal Air Force. A three-dimension radar, it is light in weight and transportable by land, sea and air. The TPS-34 employs two simple fan-beams (producing a V-beam) to obtain total volume coverage — providing accurate range, bearing and altitude data — for all targets. Its high tactical mobility, service ruggedness and all-weather reliability suit it ideally to military requirements of rapid set-up and breakdown. Electronically advanced — with modern ECCM systems — the TPS-34 is easily adaptable to a wide variety of missions. *RADIATION DIVISION, Sperry Gyroscope Company, Great Neck, New York.*

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Mergers and Acquisitions

McDonnell Aircraft Corp., St. Louis, Mo., and Hycon Manufacturing Co., Monrovia, Calif., have preliminarily agreed to McDonnell's purchase of a 55% interest in Hycon. The plan is subject to further study and approval by regulatory bodies of both firms. The two-part transaction involves McDonnell's purchase of 2,591,013 shares, about 41%, of Hycon common stock, followed by a Hycon reverse stock split of 1 for 5 and McDonnell's subsequent purchase of 400,000 shares of the new stock. Total purchase price will exceed $5,700,000. . . . *American Machine and Foundry Co., New York, has acquired the former Naval Ordnance Plant in York, Pa. The 750,000-sq.-ft. building will house AMF work on a Navy contract for anti-submarine rocket launching equipment and other supplies formerly produced at the Navy facility.* . . . Affiliated Manufacturers, Inc., Whitehouse, N.J., has acquired Automation Equipment, Inc., Wallingford, Conn., manufacturers and designers of screen printing machines for component circuitry. AEI will be operated as a fully owned subsidiary of Affiliated Manufacturers, producers of automatic and semi-automatic screen printing machines. . . . *Control Data Corp., Minneapolis, Minn., has acquired the Transacter business of General Time Corp.'s Stromberg Div., producer of the Transacter Data Collection System. The Transacter is a management tool that collects in-plant information, converts it to compter language and processes it for daily management reports.* . . . Air Reduction Co., Inc., New York City, is acquiring the assets and business of Hofman Laboratories, Inc., and its wholly owned subsidiary, Paul Chemical Co., subject to approval of Hofman stockholders. Airco is exchanging one share of its stock for each 5.78 shares of Hofman stock. . . . *Scientific Computers, Inc., Minneapolis operator of computer facilities, has purchased Workman Service, Inc., and Workman Tabulating Service, Inc., both of Minneapolis.*

Comsat Warns Speculators

The Communications Satellite Corp., expected to offer its first public stock next month, said it is warning potential investors not to expect quick or spectacular profits from the firm's stock. In its first annual report to the White House, the firm said it especially wants to inform people not experienced in buying securities.

Bureau of Standards Revamped

The National Bureau of Standards will undergo a major structural reorganization, the Dept. of Commerce announced. In order to align the Bureau, originally created to aid developing industry, more closely to "the specific needs of science, industry and commerce," four new autonomous divisions will be created. They include the Institute for Applied Technology, the Institute for Basic Standards, the Institute for Materials Research and the Central Radio Propagation Laboratory. The Institute for Applied Technology, in particular, is viewed as a step toward making science more useful to industry.

New Activities

Ledbetter Associaties, a West Coast engineering representative for electronic and electromechanical equipment, has organized its three offices under a divisional status. Headquarters for the Southern California Div. will be in Los Angeles, the Northern California Div. in San Francisco, and the Northwest Div. in Seattle, Wash. . . . *Varian Associates, Palo Alto, Calif., has established a new operating unit, Quantum Electronic Devices, to develop and manufacture advanced devices using quantum resonance techniques. The new unit, part of Varian's Instrument Group, will be located in Beverly, Mass.*

International

General Telephone & Electronics International, Inc., has purchased a 49% stock interest in Marelli Lenkurt, S.p.A., Milan, Italy, from Fabbrica Italiana Magneti Marelli, also of Milan. The purchase gives GT&E all of the issued capital stock of Marelli Lenkurt, producer of microwave radio and carrier communications equipment. . . . *Sprague Engineering Div. of Teledyne, Inc., Gardena, Calif., has been licensed by Atlas Copco A.B., Stockholm, Sweden, to manufacture the Swedish firm's jet engine starters in the United States.*

Industry Facilities

Air Products & Chemicals, Inc., Allentown, Pa., has announced plans to build a $12-million liquid hydrogen plant in New Orleans, La. The facility will fill future requirements of NASA's Mississippi Test Facility and Marshall Space Flight Center. . . . *Kollsman Instrument Corp., Elmhurst, N.Y., had created a Corporate Technology Center for advanced development engineering and scientific investigation. The center initially will be staffed by scientists and specialists from the firm's Research and Corporate Engineering Divisions.* . . . Long-Lok Corp., Los Angeles, has opened a manufacturing and sales facility at Fort Worth, Texas. The branch, to be known at Long-Lok Texas Corp., will serve missile/space and industrial requirements in New Mexico, Oklahoma, Texas and the Gulf Coast area. Long-Lok produces self-locking fasteners. . . . *A nine-story hydrodynamics test facility to evaluate performance of missiles when entering or leaving water at high velocities is being designed by Burns and Roe, Inc., New York City. The tank and associated instrumentation was specified by the Naval Ordnance Laboratory at White Oak, Md., under $240,000-contract from the U.S. Navy. The facility will reduce the need to field-test costly full-scale missiles since its 75-ft. high tank is built to handle large-scale models.*

contracts

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$4,700,000—**Lockheed Missiles and Space Co.**, Sunnyvale, Calif., for *Agena-D* booster launch services at the Pacific Missile Range.

$4,500,000—**General Electric Co.**, Philadelphia, for work on a maneuverable ballistic missile re-entry system.

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$32,004—**Flight Services Laboratory, Inc.**, Buffalo, N.Y, for continuation of research on simulation of hypervelocity aerophysical phenomena.

$28,508—**Space Sciences, Inc**, Natick, Mass., for continuation of research on drag in rarefied gases.

ARMY

$7,100,000—**Franchi Construction Co.**, for construction of the NASA Launch Operation Center's headquarters building at Merritt Island, Fla.

$2,700,000—**Raytheon Co.**, Lexington, Mass., for design and development work related to the *Hawk* missile.

$2,000,000—**Martin Co., Orlando Div.**, Fla., for production of modification kits for the *Pershing* missile system.

$2,000,000—**General Electric Co.**, Pittsfield, Mass., for manufacture of modification kits and test gear for *Polaris* fire-control systems.

$166,000—**Sylvania Electric Products, Inc.**, Mountain View, Calif., for a study of various missile systems.

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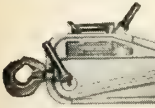
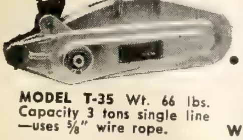


MODEL T-20 Wt. 42 lbs.
Capacity 1½ tons single line—uses ½'' wire rope.
FSN 3950-729-6165
FSN 3950-893-4342



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$8,558,280—**Raytheon Co. Space and Information Systems Div.**, Sudbury, Mass., for production of electronic guidance units for the Mark II *Polaris* missile system.

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$58,629—**Sanders Associates, Inc.**, Bedford, Mass., for performance of a research and development program on a pulse Doppler seeker.

$49,093—**Operations Research, Inc.**, Silver Spring, Md., for advanced anti-submarine torpedo studies.

NASA

$1,000,000—**Radio Corp. of America, Data Systems Div.**, Van Nuys, Calif., for construction of five display systems for the automated launch and checkout system of the *Saturn* rocket vehicle at the Marshall Space Flight Center.

$256,267—**University of Michigan**, Ann Arbor, for development and application of the thermosphere probe.

$204,134—**Lear Siegler, Inc.**, Anaheim, Calif., for multiplexing systems.

$189,000—**Ball Brothers Research Corp.**, Boulder, Colo., for an antenna system and AM receivers.

$127,754—**Wilmot Castle Co.**, Rochester, N.Y., for research studies on sterilization of space probe components.

$120,000—**Control Data Corp.**, Rockville, Md., for a computer and printer.

$59,600—**Martin Marietta Corp., Space Systems Div.**, Baltimore, for investigation of a pilot compartment airbag restraint system.

$58,690—**G.P.S. Instrument Co., Inc.**, Newton, Mass., for a high-speed solid-state 48-amplifier analog computer.

$49,325—**Republic Aviation Corp.**, Farmingdale, N.Y., for research on micro-miniature passive telemetry for biological measurements.

$46,400—**High Voltage Engineering Corp.**, Burlington, Mass., for a positive ion accelerator.

$36,465—**United Aircraft Corp., Hamilton Standard Div.**, Windsor Locks, Conn., for monograph preparation related to medical and scientific utilization of telemetry systems.

$26,997—**Electro Control Systems**, Fairmont, W.Va., for a temperature controller and recorder unit.

Kaman Aircraft Corp., Bloomfield, Conn., for study of a gyroscopic vibration absorber (undisclosed amount).

INDUSTRY

$12,000,000—**Douglas Aircraft Co., Missile and Space Systems Div.**, Santa Monica, Calif., from **Bell Telephone Laboratories**, for continuation of research and development of the *Nike-Zeus* missile as part of the *Nike-X* anti-missile system.

$4,500,000—**Arde-Portland, Inc.**, Paramus, N.J., from **Thiokol Chemical Corp.**, for equipment for the *Minuteman* ICBM first stage.

$4,000,000—**Marquardt Corp.**, Van Nuys, Calif., from **Aerojet-General Corp.**, for production of additional nozzles for the *Polaris* missile.

$2,249,303—**Ling-Temco-Vought, Inc., LTV Ling Electronics Div.**, Anaheim, Calif., from **Stanford University's Linear Accelerator Center**, for super-power pulse modulators.

$650,000—**Electronic Memories, Inc.**, Hawthorne, Calif., from **Space Technology Laboratories**, for development and delivery of severe environment satellite memory system for use in the Nuclear Detection Satellite and Spacecraft Program No. 823.

$500,000—**Acoustica Associates, Inc.**, Los Angeles, from **North American Aviation's Space and Information Systems Div.**, for production of liquid gaging equipment for use on the second stage of the *Saturn V* Moon rocket.

$200,000—**International Telephone and Telegraph Corp.**, San Fernando, Calif., from **Collins Radio Co.**, for spacecraft tracking receivers for the Rosman, N.C., wideband data-acquisition antenna station of NASA.

$87,000—**Perkin-Elmer Corp.**, Norwalk, Conn., from **Minneapolis-Honeywell** for design and construction of an electro-optical instrument for pre-launch alignment of the *Centaur* rocket's guidance system.

$55,000—**Northrop Corp., Ventura Div.**, Calif., from the **Boeing Co.**, for manufacture of high-temperate plastic heat deflectors for the improved *Minuteman* missile.

IT&T Industrial Products Div., San Fernando, Calif., from **Northrop Corp.'s Norair Div.**, for production of airborne missile launcher power supplies for the *Sidewinder* missile to be carried by the F-5 fighter aircraft (undisclosed amount).

IT&T Industrial Products Div., San Fernando, Calif., from **Minneapolis-Honeywell**, for specially designed, large-screen medical oscilloscopes (undisclosed amount).

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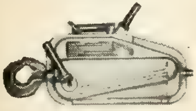

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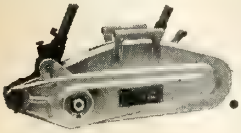

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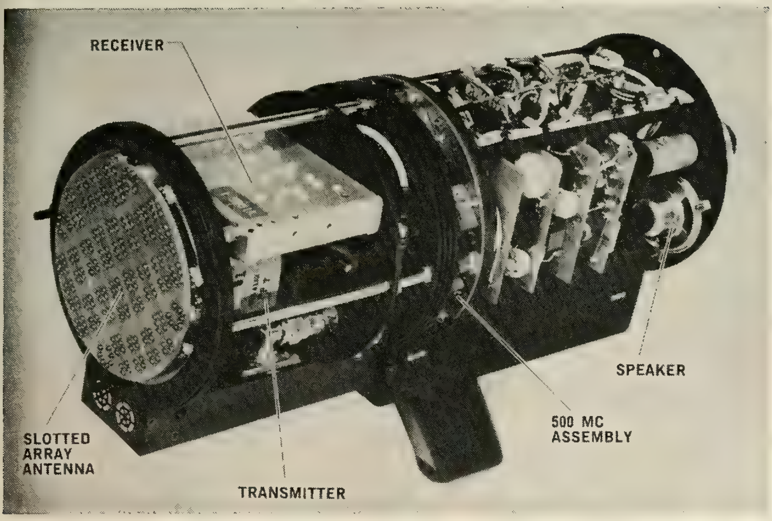

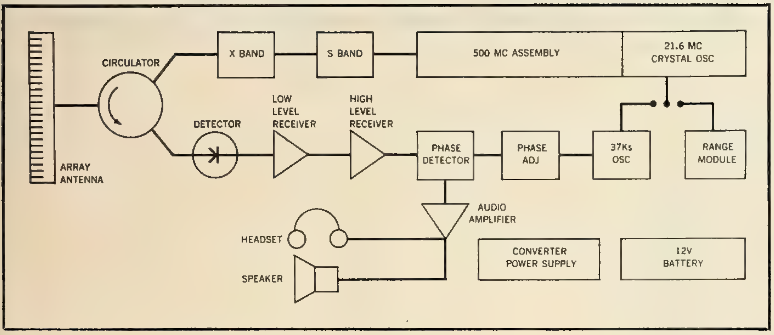

New Product of the Week: Hand-Held Radar

Prototype of a hand-carried, self-powered radar for use in military or commercial applications has been developed and built by General Dynamics/Electronics.

The device offers all-range coherent doppler detection and gives the user a choice of receiving audio signals through a loudspeaker or earphones. The solid-state FM-CW system has an X-band transmitter that is a crystal-controlled multiple chain, which can be frequency modulated. The antenna is a four-quadrant fed slotted array with a bandwidth of 200 mc. The sum pattern of 16 degrees may be programmed in a conical scan or lobe switch function.

Circle No. 151 on Subscriber Service Card

Commutator

A 108-tap, 3-gang commutator for such applications as radar displays, sequential visual indication or recording of multiple test points has been developed by Computer Instruments Corp.

The Model 315 presents 18 different points in the display system at a rate of 15 times a second. Each gang of the unit has 36 isolated segments, 20 ma capacity per segment and a starting torque of 0.5 in.-oz.

Circle No. 152 on Subscriber Service Card

Heating/Cooling Panel

A low-pressure titanium heating or cooling panel that can be directly immersed into corrosive plating fluids is available from Dean Products, Inc.

The panel, called Paneldean, is composed of grade A-35 titanium as a weldment of two plates, embossed to form fluid flow channels. The sheet can withstand 30 psig working pressure at 275°F. Sizes range from 11 to 36 in. in width and 23 to 71 in. in length.

Circle No. 153 on Subscriber Service Card

Step-Function Generator

The Model 6710 step-function generator with a rise time of less than 0.35 nanosec. is being marketed by Texas Instruments, Inc.

The device features a fall time of less than 30 nanosec. and simultaneous positive and negative output pulse which can be varied from 8 to 12v into a 50-ohm load. Repetition rate is variable from 30 cps to 100 kc in seven ranges. Pulse width varies from 100 nanosec. to 1 microsec.; delay varies from 75 nanosec. to 1 microsec.

Circle No. 154 on Subscriber Service Card

Spectrophotometer

A spectrophotometer with dual monochromatic wavelength operation that eliminates nonspecific light scattering changes is being marketed by American Instrument Co., Inc.

The unit is composed of a duochromator, an electronic console and a time-base recorder which alternate two monochromatic light beams from a single source through a sample in order to measure and record the minute transmission variations.

The device detects optical density changes as small as 0.0004 units and records changes on the order of tenths of a second. Results can be obtained in solutions with optical densities as high as three.

Circle No. 155 on Subscriber Service Card

Log Periodic Antenna

A horizontally polarized, onmi-directional, log periodic antenna, the Model AR16, is being marketed by Dorne and Margolin, Inc.

The aluminum structure has an operating frequency range of 30 to 260 mc and can withstand winds to 100 mph or ice loading to ½ in. with 50 mph winds. The standard unit is equipped with a female type "N" input connector and handles average powers up to 10 kw. It is also available with a standard LC type coaxial connector.

Circle No. 156 on Subscriber Service Card

Null Detector

A portable null detector designed to replace light-beam galvanometers and ac-operated electronic detectors is being marketed by Allegany Instrument Co.

The Model ND-2 is a solid-state instrument with self-contained mercury batteries providing 5,000-hr. life. Controls provided include on-off, adjustable coarse and fine sensitivity and zero ad-

missiles and rockets

DOD Military System

A Report on the DDR&E

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Issue Date: March 30, 1964

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The DOD Military Systems

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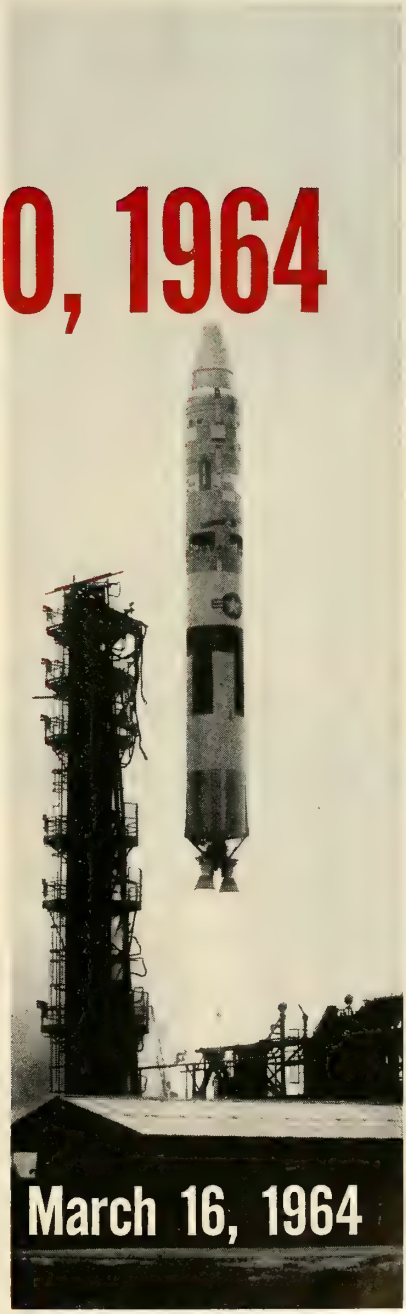

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just for balancing. Voltage sensitivity is 0.2 μv/mm. Maximum signal input is 10v at any sensitivity with overload recovery time of less than two seconds.

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Dual Discriminator

A dual discriminator using tunnel diode circuitry for pulse height discrimination, pulse shaping and standardizing has been announced by Chronetics, Inc.

The Model 101 is capable of operation at asynchronous repetition rates to 100 megapulses/sec. It consists of two isolated, electrically independent pulse shaping circuits in a single module. Each section will accept input pulses over a —100 mv to —5v range (into 50 ohms) with reflections of less than 12%. Input coupling may be dc-zero or ac; the input circuit is protected over the range 2 to —5v. Three outputs are available for each section.

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Magnetic Alloy

A high-permeability magnetic alloy, 79% nickel, 4% molybdenum and the balance iron, is available from Westinghouse Materials Manufacturing Div.

The alloy, named Hipernom, has a specific gravity of 8.74 gm/cc, a density of 0.316 lbs./cu. in., a Curie temperature of 460° C, and a melting point of 1,450° C.

The alloy was designed for applications requiring maximum flux from minimum exciting currents, minimum losses and divergency of stray magnetic fields.

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Temperature Probe

A dual-temperature, platinum resistance temperature probe is being marketed by Trans-Sonics, Inc.

Designed for use in cryogenic materials, the probe is mandril-wound and has an accuracy of ±0.75% of range. Repeatability is ±0.2% of range. It can withstand 20 g's, 20 to 2,000 cps, for protracted periods of time.

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Reed Switch

A reed switch with a mean-time-to-first-error of 125 million operations is available from Industrial Products Div. of International Business Machines Corp.

The unit is packaged in an inert-gas filled envelope and incorporates a two-cantilever beam construction. Dimensions are 0.106 in. in diameter and 0.845 in. in length.

Specifications include: maximum power, 12va; maximum voltage, 48v dc and 110v ac; maximum current, 250 milliamps, switching. Operating time is less than one millisecond, including bounce. Error rate is zero for 99.5% at 90% confidence level in 5 x 10^6 operations.

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Dual-Frequency Motors

Aerospace Electrical Div. of Westinghouse Electric Corp. is marketing a line of dual-frequency motors for use in aerospace and ground support equipment applications.

The units can be operated from either a 60- or 400-cycle power source and meet MIL-M-7969 and MIL-E-5272 specifications. An automatic frequency selector prevents operating the motor at the wrong frequency.

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new literature

CURRENT SENSING AMPLIFIERS—Military Systems Div. of Magnetic Controls Co. has published a booklet explaining the use of magnetic amplifiers as current sensors in telemetry and instrumentation applications. The booklet covers design approaches such as input/output requirements, and includes schematics, input/output curves and detailed data.

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POTENTIOMETER GUIDE—"A Designer's Guide to Precision Potentiometer Selection" is available from Perkin-Elmer Corp. The 4-page publication includes charts and tables showing major operating parameters such as linearity, loading error, resolution and phase shift under dynamic operating conditions. Loaded linearity curves, applicable to characteristics of any precision dc resistance potentiometer, are provided.

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ELECTROFORMING TECHNIQUES—Bart Manufacturing Corp. has available a 16-page technical brochure describing electroforming as a manufacturing method, particularly in microwave applications. The illustrated booklet describes the process from selection of a matrix material to final machining and grinding.

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CURING AGENT CHART—Columbia Technical Corp. has available a chart of proprietary curing agents for epoxy resin systems. It includes a listing of over 40 physical, thermal, chemical and electrical properties to aid in selection of the proper curing agent.

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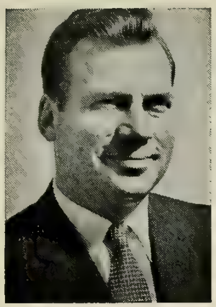
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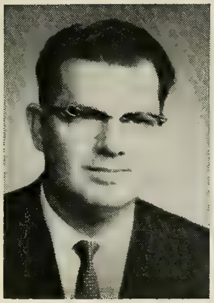
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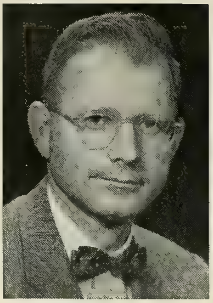
HAUSMAN

OSBORN

Emmet G. Cameron: Named vice president-engineering for Varian Associates, Palo Alto, Calif.

Russell R. McBride: Appointed manager of marketing for the West Coast operations of Electro-Optical Div. of Perkin-Elmer Corp., Costa Mesa, Calif.

Theodore W. Cooper: Joined Centralab, the electronics division of Globe-Union Inc., Milwaukee, Wis., as manager, development engineering, PEC integrated circuits and capacitors.

Samuel C. Hamilton: Appointed senior vice president-financial of Chicago Bridge and Iron Co., Oak Brook, Ill.

Arthur H. Hausman: Appointed vice president-operations for Ampex Corp., Redwood City, Calif.

Milton F. Pravda: Named director of engineering and research for Martin Co.'s Nuclear Div., Baltimore.

W. E. Fore: Appointed vice president-manufacturing facilities at Rocketdyne Div. of North American Aviation, Inc., Canoga Park, Calif. **P. J. Fritch** appointed vice president-controller/financial; **E. B. Gallant** appointed vice president-administration and **P. R. Vogt** named vice president-engineering.

Gordon L. Harris: Named chief of public affairs to supervise public information, protocol and community development offices at NASA's Kennedy Space Center, Florida.

Robert C. Orr: Appointed western field engineering manager for Lord Manufacturing Co., Erie, Pa. **Edward J. Conway** named manager of the Kansas City office. **Robert L. Peterson** promoted to manager of the San Francisco office.

William L. Gore: Named senior vice president-sales for Aerojet-General Corp., El Monte, Calif.

Ralph J. Osborn: Elected a Lockheed Aircraft Corp. group vice president in charge of Lockheed Aircraft Co., Ontario, Calif.; Lockheed Electronics Co., Plainfield, N.J.; and Puget Sound Bridge & Dry Dock Co., Seattle.

M. J. Richardson: Appointed director of marketing and contracts at Mechanics Research, Inc., El Segundo, Calif.

Larry Cox: Joined Dearborn Electronic Laboratories, Inc., Orlando, as national sales manager.

Fred W. Wolcott: Elected vice president for operation at Research Analysis Corp., McLean, Va. **Hugh M. Cole** elected vice president for operations analysis.

J. Edmund Fitzgerald: Named director of research and engineering at Lockheed Propulsion Co., Redlands, Calif. **Dr. C. James Barr** named director of operations.

Ralph J. Halk, Appointed controller of Applied Technology, Inc., Palo Alto, Calif.

Morton L. Long: Appointed general manager of the TechRep Div. of Philco Corp., Philadelphia.

William J. Conner, Jr.: Named manager-marketing for the General Electric Co.'s Military Communications Dept., Oklahoma City, Okla.

Robert A. Ehlert: Appointed a district representative of the Nortronics Div. of Northrop Corp. for the central regional marketing area with headquarters in Dayton, Ohio.

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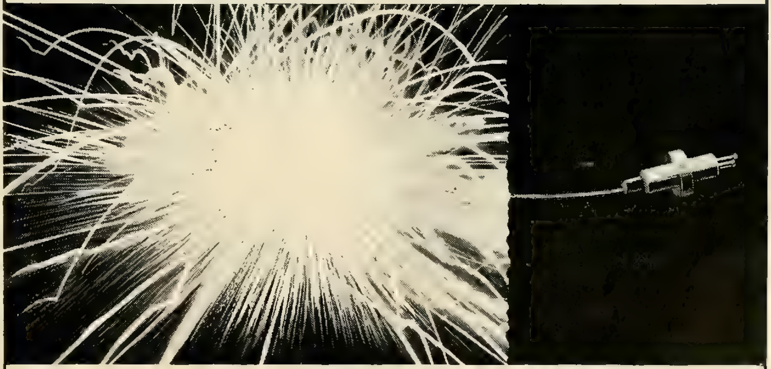

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—when and where—

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International Solid State Circuits Conference, sponsored by IEEE and the University of Pennsylvania, Sheraton Hotel and University of Pennsylvania, Philadelphia, Feb. 19-21.

Pricing and Negotiating Prime and Sub-Contracts in the Defense and Aerospace Industries Seminar, sponsored by the Contract Management Institute, Savoy-Hilton Hotel, New York City, Feb. 24-28.

Ninth Scintillation and Semiconductor Counter Symposium, sponsored by IEEE, AEC and NBS, Shoreham Hotel, Washington, D.C., Feb. 26-28.

MARCH

ASME Gas Turbine Conference and Products Show, Shamrock Hilton Hotel, Houston, Mar. 1-5.

Atmospheric Problems of Aerospace Vehicles, sponsored by FAA and AMS, National Aviation Facilities Experimental, Atlantic City, N.J., Mar. 2-5.

15th Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Penn-Sheraton Hotel, Pittsburgh, Mar. 2-6.

Fifth Symposium on Thermal Radiation of Solids, Sheraton-Palace Hotel, San Francisco, Mar. 4-6.

Southeastern Conference on Theoretical and Applied Mechanics, Georgia Institute of Technology, Atlanta, Mar. 5-6.

AIAA Aerodynamic Testing Conference, Marriott Twin Bridges Motor Hotel, Washington, D.C., Mar. 9-10.

National Association of Corrosion Engineers Annual Conference and Corrosion Show, Sherman Hotel, Chicago, Mar. 9-13.

Air Force Cambridge Research Laboratories Exploding Wire Conference, Kenmore Hotel, Boston, Mar. 10-12.

Society for Nondestructive Testing Spring National Convention, Chapman-Park Hotel, Los Angeles, Mar. 16-19.

NBS Symposium on Statistical Association Methods for Mechanized Documentation, National Bureau of Standards, Washington, D.C., Mar. 17-19.

Third Hypervelocity Techniques Symposium, Denver, Mar. 17-18.

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editorial . . .

That Boston Center

WE HAVE NOW ENTERED a suspenseful 45-day period in which Congress must decide if it will act on the latest recommendation of the National Aeronautics and Space Administration regarding its proposed electronics research center.

Last year, NASA proposed that the $50-million center be located in the Boston area. Congress asked the space agency for further justification of the center and its location.

After a series of presentations by other interested areas, NASA Administrator James Webb has reaffirmed the agency's choice of Boston as the preferred site—to the surprise of almost no one.

NASA will be permitted to proceed on this basis if the recommendation is not vetoed by Congress within 45 days.

We favor such a veto.

We favor it on an issue far more fundamental than that of location. We do not believe NASA has submitted convincing proof of the need for such a center.

We have read the space agency's detailed justification. We have talked to responsible electronics authorities in both industry and government. We have, within the past week, talked to corporate officers of a number of electronics firms in the Boston area. These have been firms which, in some cases, have supported the move to bring a NASA electronics center to Boston.

More than one of these officials has admitted, in effect: "We do not see any requirement for such a center. But if there is to be one, and it appears there is, then we want it in the Boston area."

The reason for this is frankly expressed self-interest. Many Massachusetts electronics firms at first feared, and openly opposed, establishment of the center in their backyard. The reason: concern over competition for scientific talent.

On further examination, this fear faded with the realization that establishment of the center nearby undoubtedly would lead to more business for firms in the Boston area. Despite NASA pledges that its principal concern would be in-house research, the history of such enterprises in the past indicated it soon would be turning to more ambitious projects.

It is not surprising, therefore, that a number of Boston area firms have campaigned both quietly and effectively in behalf of the center. More of a surprise, perhaps, is the fact that some of those who have been most active in this campaign will answer with an honest negative the basic question of whether such a center really is needed.

That NASA needs an additional electronics capability, particularly one to provide increased reliability, is not questioned. But NASA has not built a convincing case that this capability should be isolated in one corner of the nation, far from the NASA centers deeply engaged in manned and unmanned flight programs.

If funds are to be provided for this purpose, they should be devoted to strengthening electronics know-how at the program-oriented centers where it is directly applicable.

NASA's own plea in support of the proposed center, that electronics makes up at least 70 percent of each space vehicle, is in itself an argument for building this capability at the existing centers, not at an academic cell placed conveniently near the fine universities of the Northeast.

A further argument against the proposed new facility is that it comes too late in time to contribute in any substantial manner to the *Apollo* program. If we can go to the Moon without it, we can do a number of other things without it. Under any NASA budget, and particularly under the present severely restricted space agency budget, the proposed electronics center is a luxury we can ill afford. Congress should act to kill it during this 45-day period.

Our deep concern continues, not only with this facility, but with the proliferation of organizations in the university, non-profit and government fields which are doing work which can be done more effectively by private industry.

The necessity of staying in business, and showing a profit to the stockholders at the end of the year, is a powerful motivating force toward an economic and effective operation.

CONSIDER, THEN, the recruiting advertisement in the *New York Times* on January 26 on behalf of the U.S. Naval Laboratories in the Washington, D.C., area. This offered a promising future "free from the job-permanence worries that plague the defense industry these days."

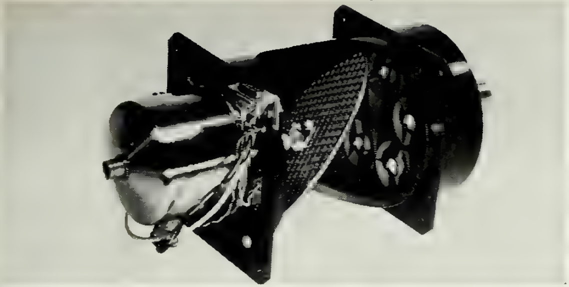
We suggest you read that novel and interesting thought again. The Naval Laboratories—the Naval Laboratories, mind you—are free of the uncertainty surrounding a fluctuating military budget. Nor is this just research activity. At the Naval Propellant Plant, for example, "they manufacture, inspect, test, and deliver missile propulsion units, too."

Industry frequently concerns itself with the role of the non-profit corporation. Yet Dr. C. W. Halligan, president of Mitre Corp., had a word to say in a recent issue of *Industrial Research* which might be very applicable to the Navy activity described above. He said: "The company must not take on work that can be done more appropriately by other available sources. The company must avoid extending the scope of its work into areas that belong to others. This is especially true of the proper fields of industry, such as detailed design and manufacture."

We suggest that the Navy, engaging in the manufacture of missile propulsion units while attempting to lure talent from industry with promises of freedom from the "job-permanence worries" plaguing that same industry, is perverting the free enterprise system it serves.

Someone should be horsewhipped for this, as the country editors used to say. Then another country implement, the axe, should be used on NASA's proposed electronics research center, on the U.S. Naval Laboratories and on a great many more of these swollen parasites on the free enterprise system.

William J. Coughlin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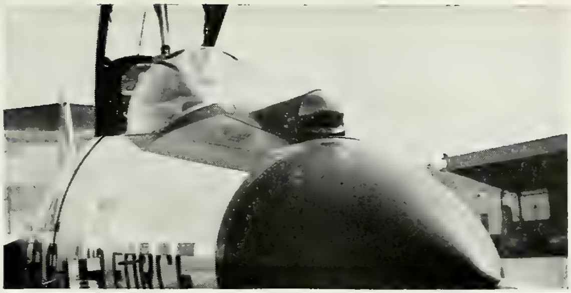

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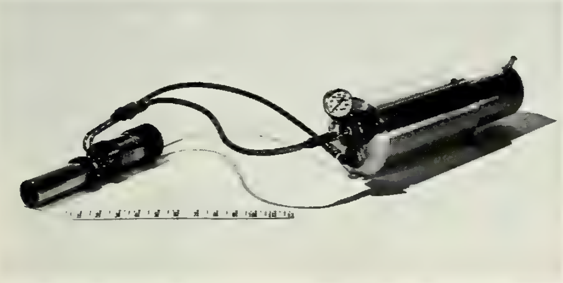
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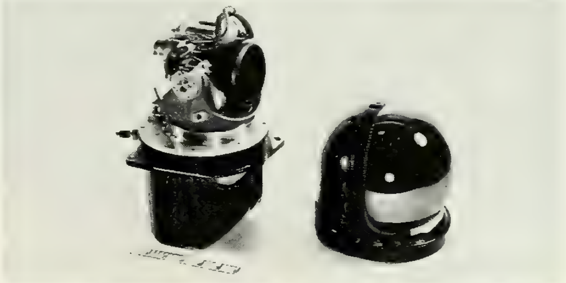
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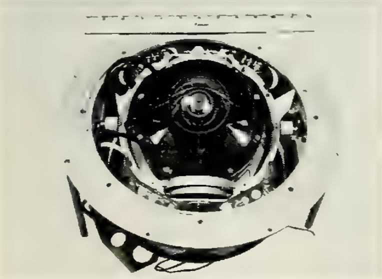
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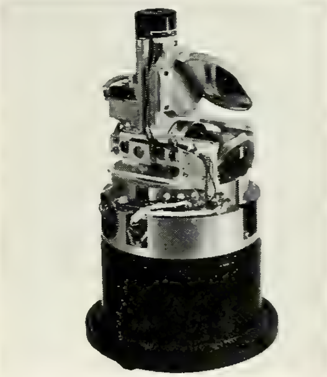
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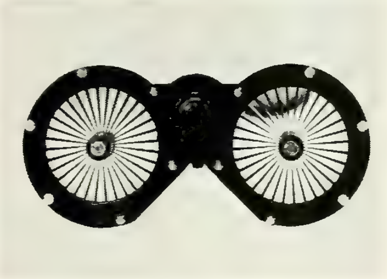
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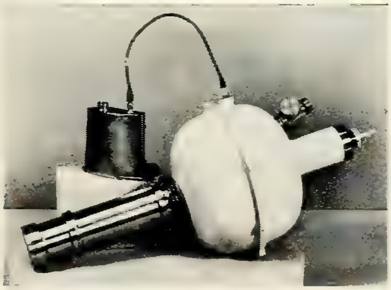
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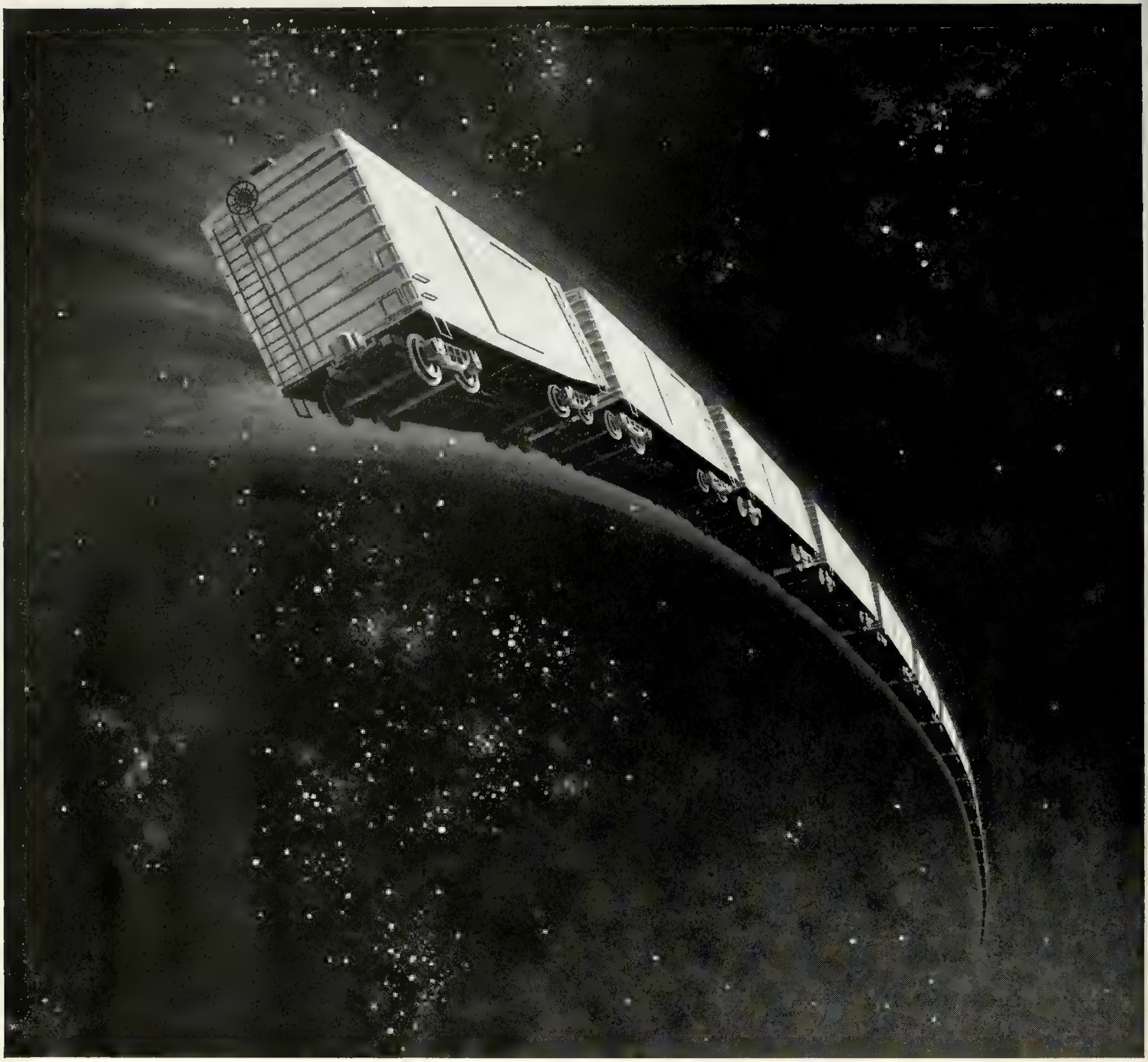

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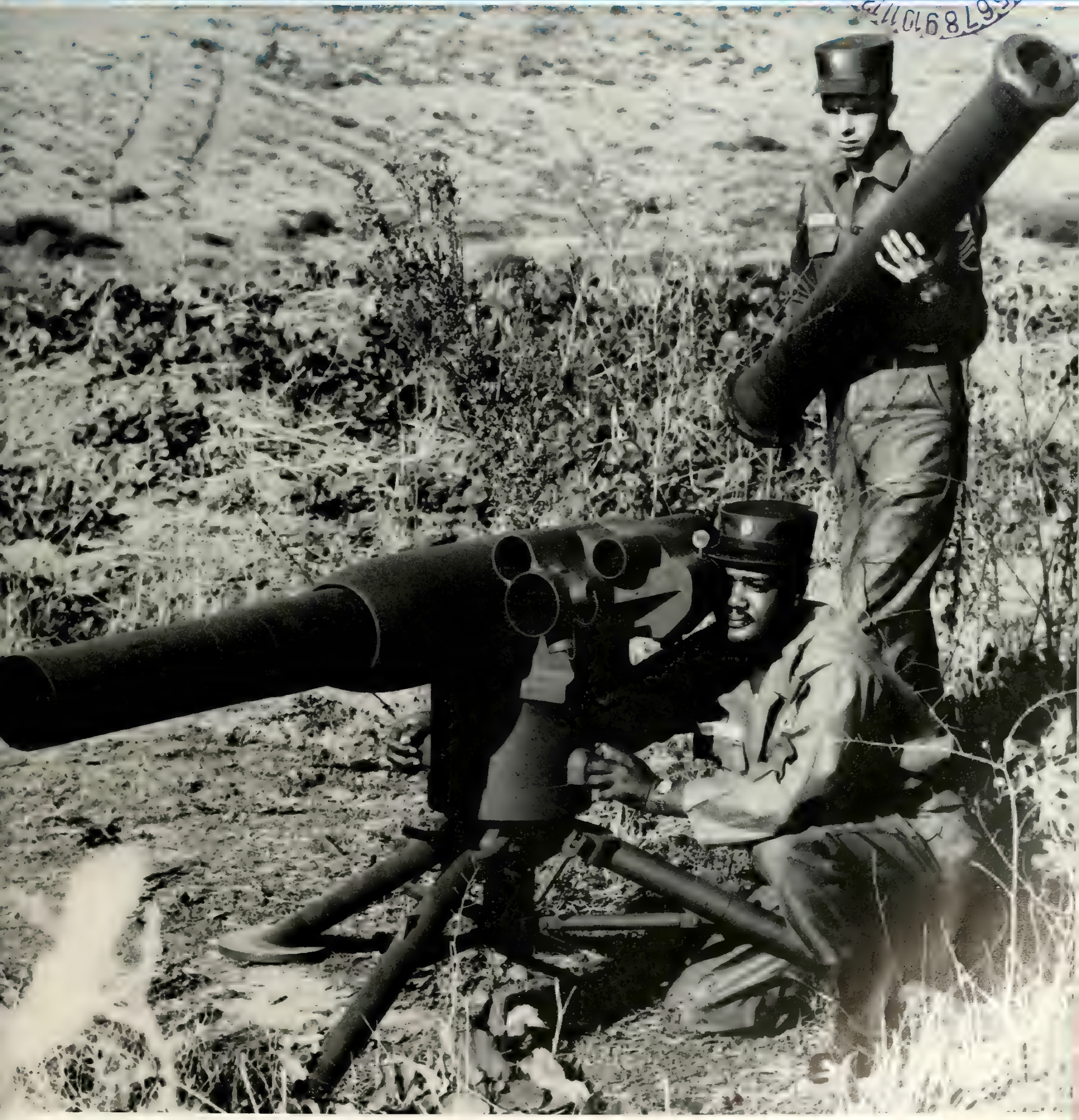

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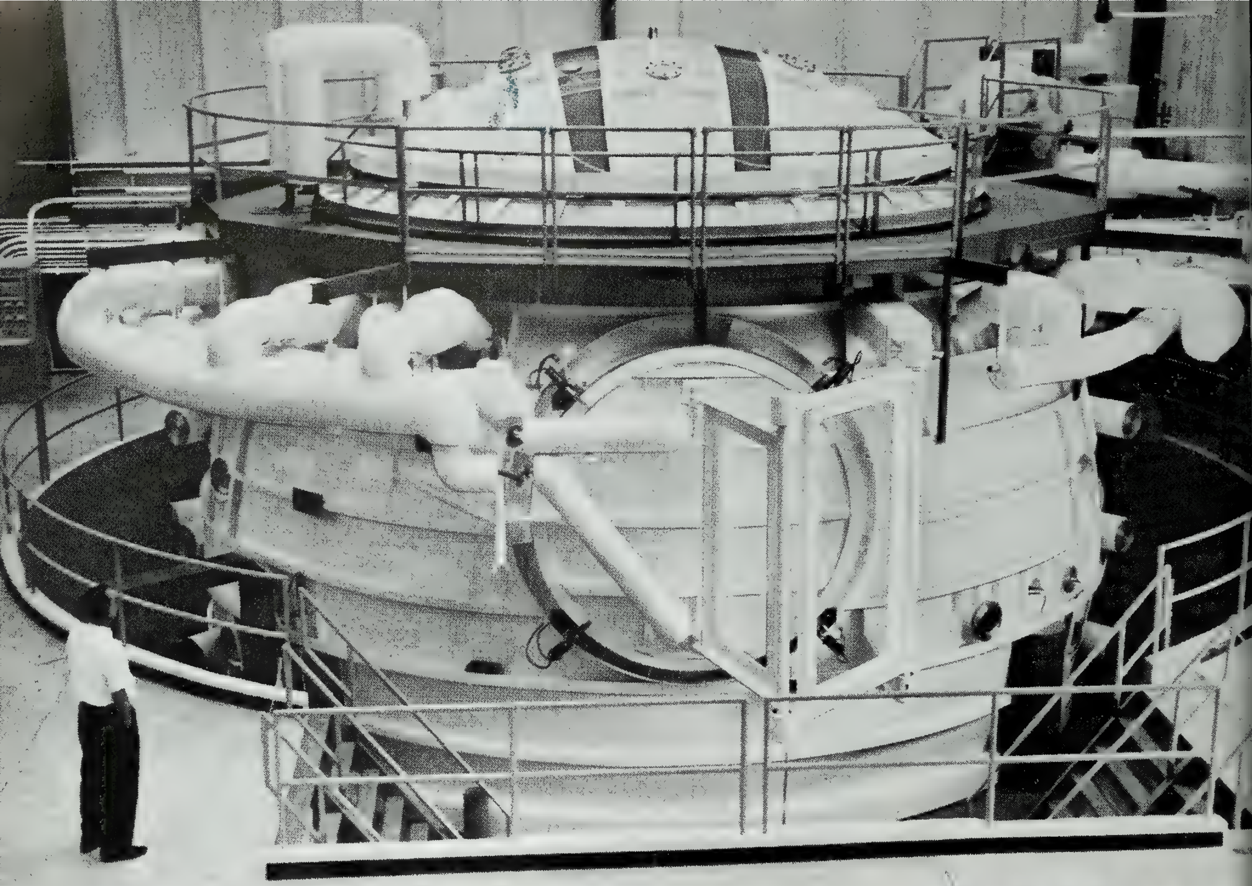


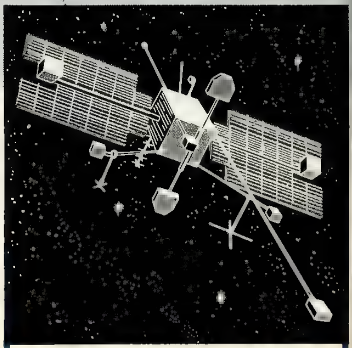
OGO'S OUTER SPACE TEST TUBE A COMPLETE PROJECT BY CB&I

A new space simulation system which is now being used to test NASA's Orbiting Geophysical Observatory (OGO) spacecraft was completely designed and supplied by CB&I.

This is the largest system designed and supplied by a single contractor, without subcontracting the chamber, thermal system or vacuum system.

CB&I was awarded the complete project by TRW Space Technology Laboratories, designer and builder of OGO and other spacecraft in the nation's major space programs. The TRW installation is further demonstration of CB&I's outstanding reputation for designing, fabricating and constructing complete space simulation systems.

The next time you have an environmental testing system to be built —for space simulation or not—call on CB&I's complete capabilities. A "world of experience" awaits your inquiry. Chicago Bridge & Iron Company, Oak Brook, Illinois. Offices and subsidiaries throughout the world.



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The high vacuum and temperature extremes needed to bring outer space down to earth are created inside a 30-foot diameter stainless steel Hortonsphere.® Here vacuums to 3x10^{-9} torr (equal to a 380-mile altitude) will be reached, with temperatures from −30 to +275°F.

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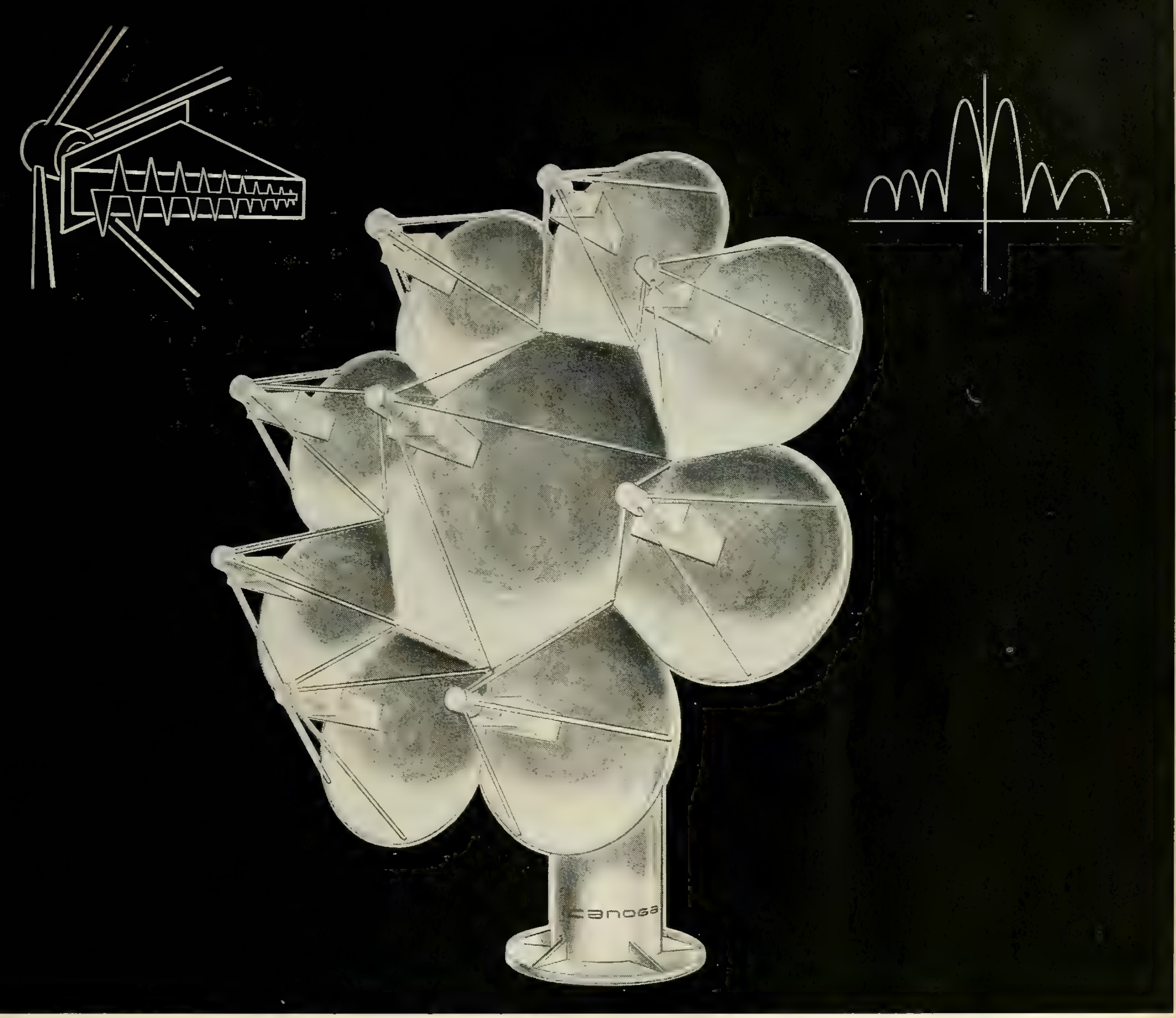
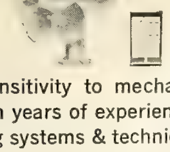


WIDEBAND TRACKER

canoga



Canoga currently has under development broadband tracking antennas in the 200-2400 mc and 1000-12000 mc frequency regions. These "Sunflower" monopulse tracking antennas contain nine reflectors, each with its own log periodic feed element of 12:1 frequency bandwidth. Featuring low sidelobes, low antenna noise temperature, high aperture efficiency and relative insensitivity to mechanical tolerances, the Sunflower antenna design is predicated on years of experience in the development of Mercury and Gemini telemetry tracking systems & techniques. It is one of a family of new tracking system developments from Canoga.

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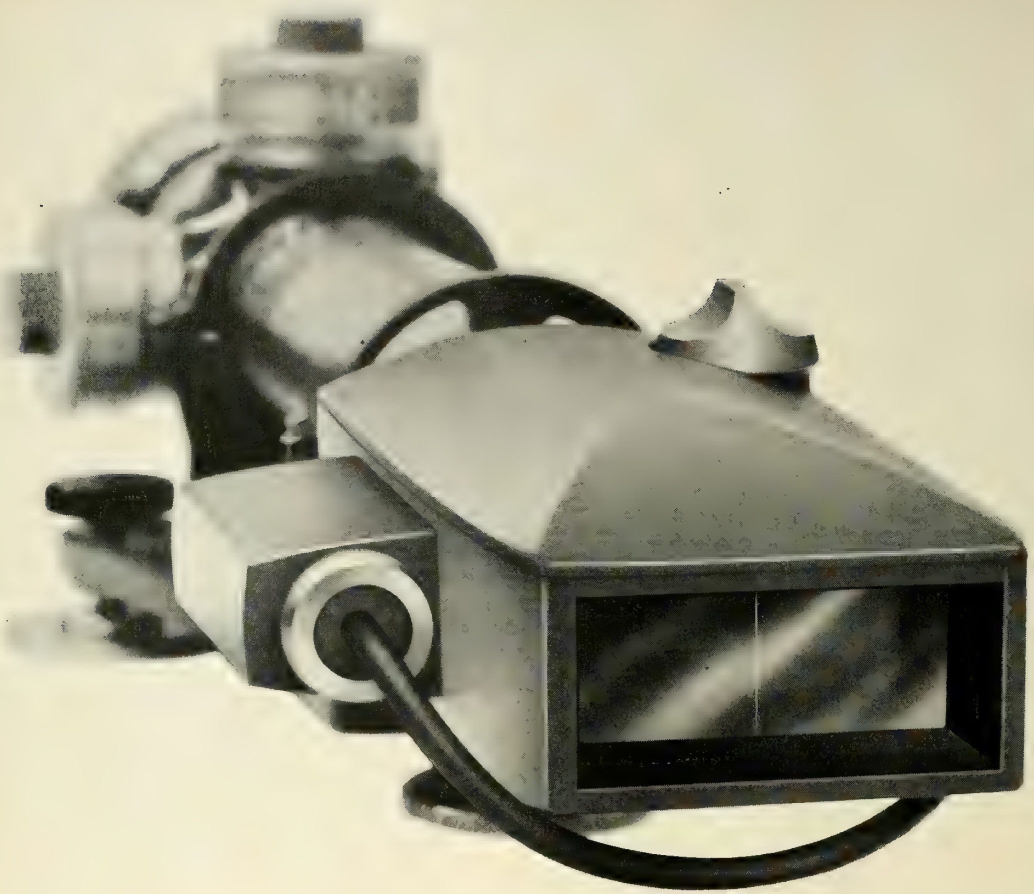

New angle-measuring interferometer

Kollmorgen Model K-421 brings 0.02 second-of-arc sensitivity out of the laboratory into practical engineering use.

Uniquely simple! Unlike conventional interferometers, portable Model 421 Pointing Interferometer has a single optical element . . . a special Koesters double-image prism having equal internal paths. Permanent calibration is inherent. Minimum operator training is required.

How it works! The four-pound Model K-421 is designed to mount on an alignment telescope having an NAS 2.25-inch diameter barrel. Two parallel beams of light are projected at a plane mirror. Mirror rotation changes the path lengths of the reflected beams and establishes an interference fringe pattern.

Highly sensitive! Model K-421 is so calibrated that one interference fringe represents a mirror rotation of one second of arc. With the optical micrometer on the Kollmorgen K-122 alignment telescope, you can subdivide each fringe into increments as small as 0.02 second of arc. With the Model K-120 Line-of-Sight Alignment Telescope, visual interpolation to 0.1 second of arc is readily attained. Rotation angles up to 2000 seconds of arc can be measured. Measurement error does not exceed 0.1 percent of measured angle, or 0.02 second of arc, whichever is larger. Maximum working distance is 25 feet.

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Informative 12-page bulletin contains complete data on Model K-421 and other new Kollmorgen optical tooling instruments: Single and Dual-Axis Autocollimators, Dual-Axis Automatic Autocollimator, Dual-Micrometer and Line-of-Sight Alignment Telescopes and all required accessories. Write today to Director of Instrument Sales for this bulletin, specifying whether you want early demonstrations.

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THE WEEKLY OF SPACE SYSTEMS ENGINEERING

Volume 14, Number 8 February 24, 1964

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THE COVER

First photo of full-scale mockup of Army's TOW antitank missile point up weapon's close-support character. The Hughes-developed missile is breech-loaded into the recoilless launcher, fired, and guided automatically to its target by a command link with the launcher-mounted optical sight.

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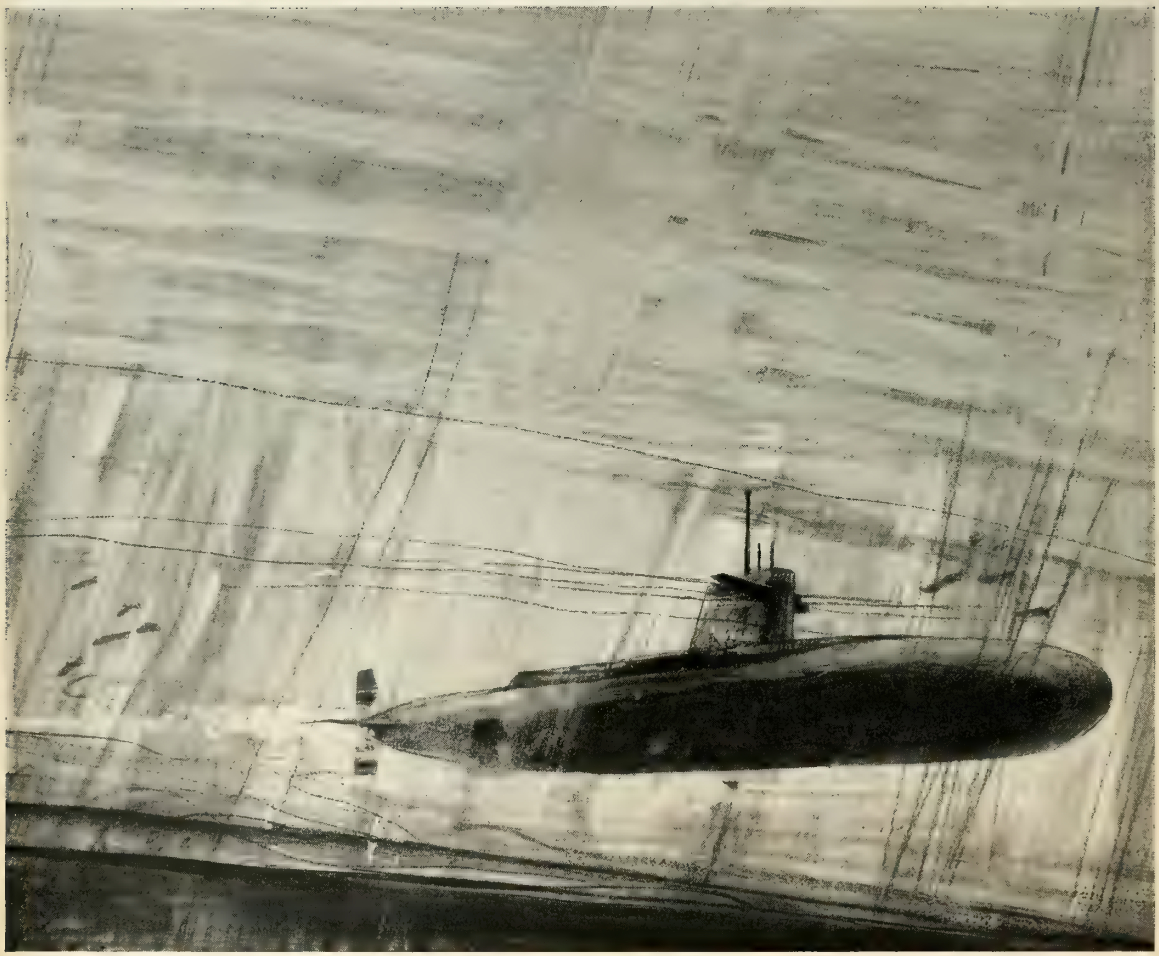
47,900 copies this issue

† U.S. Reg. Pdg.

Is this what most engineers mean when they say RELIABILITY?



An integrated inertial navigation system that can guide a nuclear-powered submarine for weeks in the ocean depths without surfacing.

That is reliability. The system is called the Mark II SINS. It was designed, developed, and produced by the Autonetics Division of North American Aviation. Today it guides the Free World's nuclear-powered, Polaris-carrying submarines, accurately giving them their position and velocity plus the direction of north at all times. It is but one of many achievements pioneered by the engineers and scientists at Autonetics in the area of integrated systems application with built-in cost effectiveness. These achievements by Autonetics have now set a new standard of reliability for the entire electronics industry.

North American Aviation / Autonetics

Ranger Management

To the Editor:

May I commend your Feb. 10 editorial ("A $150-Million Failure") as being overdue. The only possible complaint might be that it was too lenient. When Rex Pay's article on *Ranger VI* appearing in the same issue (p. 16) is considered, the conclusion is inescapable that the *Ranger* program suffers not from mismanagement, but from bungling.

The disciplines of system analysis and reliability engineering are not new: application of these techniques would have revealed the incredible naiveté underlying the design of *Ranger VI* with respect to the central computer and sequencer (CC&S) subsystem. Application of elementary control system reliable design techniques could and should, have prevented the fiasco of Feb. 2.

If I am mistaken, and the knowledge of such design techniques is in fact obscure and narrowly comprehended, I would be glad to furnish the data to NASA or JPL, free of charge.

L. E. Dostert, Jr.
Silver Spring, Md.

To the Editor:

In regards to your well-described exclamatory remarks on the failures of the (dragged out and well-publicized) *Ranger* program. Amen!

The one fault with this editorial, as well as with nearly all your others, is that it is not brought to the attention of the American public.

National apathy concerning space should be changed.

A. M. DeMark
Syracuse, N.Y.

To the Editor:

In your editorial you have, by shotgun condemnation done great disservice to all academically-managed, government-financed laboratories. The Instrumentation Laboratory and Lincoln Laboratory of MIT, as well as the Applied Physics Laboratory of Johns Hopkins, have records in space electronics which any industrial firm would find difficult to better.

You mention that "an academic environment is neither comparable nor conducive to the kind of hard-driving industrial atmosphere required to make complex hardware function in a highly reliable manner." There are two points to be made with regard to this statement. In the first place, because a laboratory is academically-managed does not make it necessarily follow that the environment at that laboratory is not, when the occasion demands it, every bit as hard-driving as any industrial concern. Secondly, it is a matter of record that the "hard-driving industrial atmosphere" produced poor results on the *Mercury* and Nuclear Submarine programs. I believe it is a true statement that had a man not been aboard the *Mercury* spacecraft during those epic flights, every shot of that series would have been written off as a failure as a result of a subsystem malfunction.

In the future let us be more specific about the praise or blame that is leveled by your editorial staff. There is too much excellent work being done by laboratories —industrial, civil service, and academically-associated—to condone continued use of the shotgun condemnation.

William G. Schmidt
Burlington, Massachusetts

To the Editor:

The Feb. 10 editorial is not worthy of your magazine or of yourself. The failure of the TV equipment on *Ranger VI* was disappointing, but certainly not enough to warrant such an impassioned outburst on your part.

First, you have distorted the statement made in the Letters column. At least one of the *Ranger* failures was due to a failure of the launch vehicle, and in view of the fact that the Air Force had complete control of the "bird" to point of injection, I fail to see any justification for your statement that responsibility for the failure should be laid at JPL's feet.

Second, I take exception to your statements that: *"Ranger I* failed. *Ranger II* failed. . . . *Ranger VI* failed." The implication is that each and every launch was a complete and utter failure. You completely ignore the fact that these were developmental launches, not proven systems. I have noticed no such scathing remarks when you refer to the spectacular failures (yes, failures) occurring during the development of Air Force missile systems. Indeed, these are listed as "partial successes," even when (in one case) the thing blew up on the pad (remember *Titan*?).

Third, you make a great to-do about the fact that JPL operates outside of Civil Service. It must have escaped your notice that the Air Force has set up numerous such organizations—Rand, Ramo-Wooldridge, Aerospace, etc. "Unwholesome" apparently depends upon whether the facility is an Air Force one?

The editorial page is an important concept. It provides a sounding board for opinions and comments which would not ordinarily be available to the reader. It is the privilege of the editor, but with any privilege goes responsibility as well.

D. Winslow
Stanford, Calif.

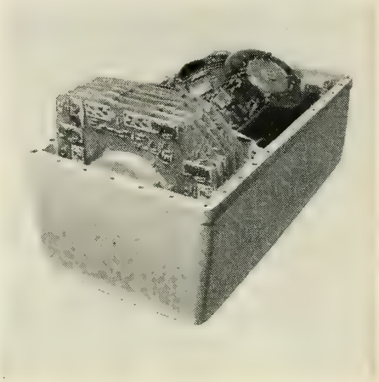
To the Editor:

Your standard for an editorial is always superb, but the one in your Feb. 10 issue demands particular acclaim.

The things said are entirely accurate, and they needed saying. If the Administration doesn't start to take a real look at NASA's lack of project management and integration ability, we are going to have a king-sized kluge on our national hands.

(Name Withheld)
Los Angeles

And is this what most engineers mean when they say APPLIED MICROELECTRONICS?



It is called the N16 Autonavigator.

The lightweight N16 Autonavigator is another major achievement in inertial navigation by the Autonetics Division of North American Aviation. Drawing on years of experience and extensive research, Autonetics engineers have applied microelectronics to navigation systems.

N16 is more than a single autonavigator. It's a whole family based on proven concepts, utilizing standardized equipment and featuring modular construction for growth potential. The basic N16 is designed specifically for high performance tactical and transport aircraft. The N16S adds capabilities required in space. The N16M accommodates the same common sub-systems to the needs of ships and submarines.

This N16 series utilizes precision gyros and velocity meters which are scaled-down versions of inertial components now used in major weapon systems. Use of microcircuitry, integrated circuits and other recently-proven techniques provides high accuracy plus a reliability 10 to 30 times that of conventional guidance systems.

The basic N16 total system weight is 40 pounds; volume, 1.0 cubic foot; and the total power consumption is only 140 watts, including the computer with its built-in self-check and calibration features.

A low total life cost is assured by the high reliability, simple operator requirements and engineered ease of maintainability.

This is but one more example of how the engineers and scientists at Autonetics are forging ahead in the field of applied microelectronics and total systems integration... another reason why Autonetics today is continuing to set standards for the entire electronics industry.

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Why use a Cyclic-to-natural Code Converter when it is no longer necessary?

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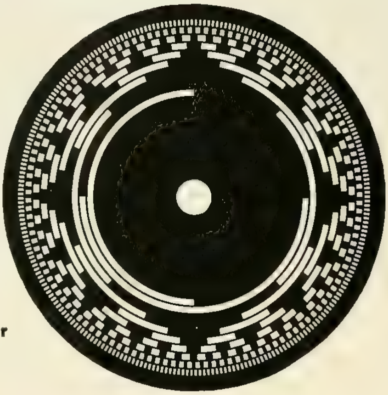
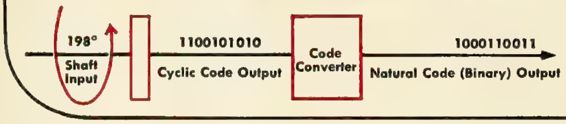
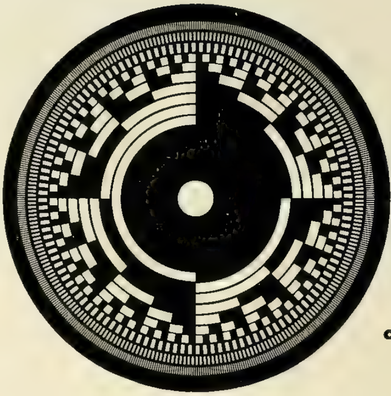
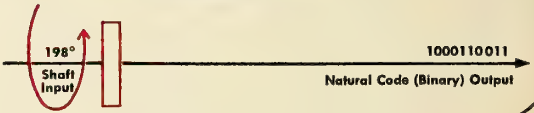


Typical Cyclic (Gray) Code Disk. Output is cyclic or inverted code and must be converted to natural form for computation.





Wayne-George Natural Code (Binary) Disk. Output is non-ambiguous, natural code produced directly without conversion from cyclic code.



Only Wayne-George offers a complete line of optical shaft-angle encoders providing direct, non-ambiguous natural code outputs without code conversion. The new DIGISEC® and "N" Series DIGISYN® encoders completely obsolete encoders using inverted or cyclic (Gray) codes and their conversion equipment.

The DIGISEC and "N" Series DIGISYN encoders cover accuracies and resolutions (per turn) ranging from several minutes of arc to one second of arc. Natural binary, binary coded decimal or other natural codes are available. Outputs are DC levels in parallel form and are continuously available. There is no limit to interrogation rate. Integral code displays can be provided.

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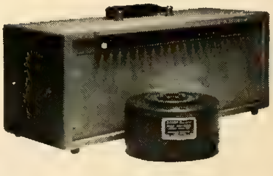
Shown is an NB-15 DIGISYN. The "N" SERIES cover the range from 5 to 17 Binary Digits.



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The Countdown

WASHINGTON

New Incentives Proposed for JPL

NASA wants to work incentive-type features into the new contract it is negotiating with Jet Propulsion Laboratory. This would include a higher fee for good performance and a penalty if JPL does not meet certain schedule and reliability standards. NASA also wants Dr. William Pickering, JPL's director, to hire an industry executive as his deputy. The space agency feels these moves would lead to the hard-headed industrial type of management it wants at JPL.

Boston Center Prospects 50-50

Opinion in the House Space Committee concerning NASA's renewed proposal to build an Electronics Research Center in Boston appears to be almost evenly split, an informal poll discloses. Outcome could depend on who shows up at a possible voting next week. But it's more likely Congress will allow itself almost the full 45 days available for a vote before the project is automatically authorized.

Cuba Lesson Well Learned

One of the most attractive features of the Air Force's *MMRBM* is that with its extreme mobility and air-transportability it could be used for much the same kind of strategic maneuver the Soviets pulled in Cuba. Introduction of such weapons into countries near the Soviet Union—at places and times of U.S. choosing—would infinitely complicate the Russians' target interception problem. Besides, say DOD officials, *MMRBM* has a longer range, greater accuracy and far greater mobility than comparable Soviet missiles.

SPADATS Accuracy To Be Improved

Air Force will start development during Fiscal '65 of a highly accurate three-site radar system using triangulation to determine very accurately the orbital parameters of satellites.

Water Landings for Apollo, Too?

NASA may well drop all plans to bring space vehicles to touchdown on land. Manned spaceflight boss Dr. George P. Mueller says he favors water landings for *Apollo* as well as for *Gemini* (see p. 21). Control difficulties are cited as the major reason for the possible changeover.

LEM Configuration Unaffected by Ranger

Design of the Lunar Excursion Module in Project *Apollo* is in no way being held up by slippage in the *Ranger* program, NASA officials report. They say the flexibility of the design gives it a 98% chance of landing on any surface.

Helicopter Arms Get More Punch

An Army study of suppressive fire systems for helicopters is investigating development of a guidance system that would work with either *TOW* or *Shillelagh*. It is pointed out that systems of this type are unsuited for present helicopters and would be elements of the armed helicopter. Experts say adaption kits won't work for something like this.

Manned Flight Staff Peaking

NASA now estimates that its scientific and engineering manpower requirements for manned spaceflight only will reach a peak in FY 1965 of 45,700, of which in-house staff will total 6,500. This will then decrease until 1970, when the total requirement will level off to 15,000, with an in-house staff of 3,800.

OSO Waste Charge Hotly Denied

The space agency will take violent exception to a report by the General Accounting Office (GAO) that money has been wasted on the *Orbiting Solar Observatory* program. Dr. Homer Newell says the agency will justify buying backup vehicles—a point singled out as wasteful by GAO—on the grounds that the program is so important that the backups are necessary. The answer is now being prepared.

Pure Oxygen Gets Preliminary Nod

A second 30-day pure-oxygen environment test has begun at the AF School of Aerospace Medicine, Brooks AFB, Tex. Although not all data from the first test have been processed, the Air Force reports a tentative OK for 30 days for the controversial spacecraft atmosphere.

INDUSTRY

Genisco Wins Space Simulation Contract

Genisco Inc. has been selected by NASA to develop a motor generator for research into guidance and psychophysiological problems of manned spaceflight. Costing an estimated $6-6.5 million, the generator will consist of a centrifuge on a 50-ft. boom, a vertical drive, a programmed braking device, fluid bearings, and two simulated space capsules with controls.

Huge Platform for Apollo Control Tests

Stabilization and control systems for the *Apollo* Command Module will be tested on a massive 2½-ton spacecraft simulation platform balanced on an air bearing. Built by Hexcel Products, Berkeley, Calif., the platform was delivered recently to Honeywell Military Products, developers of *Apollo* stabilization and control. It is 13½ ft. in diameter and consists of several layers of honeycomb core aluminum balanced on a pressurized dry nitrogen gas air bearing. The manufacturer says a load of six tons will not deflect the platform more than one 4,000th of an inch at its edge.

INTERNATIONAL

World ComSat Talks Resuming

Further talks will be held soon in Washington on the proposed world-wide communications satellite system. Some early progress was reported after three days of discussions in Rome recently. U.S. and Canadian representatives—including chairman of the board Leo D. Welch and president Joseph Charyk of the ComSat Corp.—met with the 17-nation European Conference on Satellite Communications. It was agreed that an international organization should eventually operate the global system. Still to be resolved is the question of when such an organization should take over. The U.S. favors a long initial phase under ComSat Corp. control to gain experience prior to internationalization.

Saturn SA-6 Preparations

The S-1 *Saturn I* first-stage booster and the boilerplate *Apollo* Command Module due to fly sometime this spring arrived at Cape Kennedy within a few hours of each other Feb. 19.

The S-1 *Saturn* stage was immediately taken to Complex 37B, where it was to be placed on the launch stand the next day. It was the first time such a stage was taken directly to its stand and set up without hangar checks.

Checkout of the *Apollo* spacecraft began within a few hours after it arrived by air.

Ranger VII Slips

NASA has postponed the launch of the *Ranger VII* spacecraft originally scheduled for late February.

The space agency said a new launch date would be set when a study of why *Ranger VI* failed to take pictures of the Lunar surface on its recent flight is completed.

The NASA-JPL study is concentrating on the unscheduled turn-on of telemetry from the television system, which occurred at about the time of separation of the booster engines from the *Atlas* launch vehicle.

SECOR Orbit Revealed

First of the Army's *SECOR* (*Sequential Collation of Range*) satellites known to have attained orbit "is working exceptionally well" following its launch late last month.

An earlier attempt on Jan. 24, 1962, to orbit *Composite I* containing a Type I *SECOR* plus four Navy satellites, failed because of a second-stage misfire of *Able-Star* (M/R, Jan. 29, 1962, p. 12).

Although time and place of the latest launch were not disclosed by Dr. Albert C. Hall, DDR&E deputy director for space, in a talk to the National Space Club and the Aviation/Space Writers Association last week, the Type II *SECOR* satellite presumably was one of the classified DOD payloads launched on Jan. 19 by a *Thor-Agena* from Vandenberg AFB, Calif.

In its use primarily for military purposes, *SECOR* is intended to pinpoint the geodetic coordinates of targets for U.S. ICBM's. *SECOR,* in addition, is part of NASA's *ANNA* program, which will provide geodetic data of scientific use (M/R, Feb. 6, 1961, p. 22).

Built by IT&T Labs, Nutley, N.J., *SECOR* is rectangular in shape, weighs 40 lbs., and measures 9 x 11 x 14 in. It is designed to spring free of its carrier after orbit is attained (M/R, Dec. 17, 1962, p. 16).

The first successful orbital experiment involving *SECOR* instrumentation was part of the *ANNA 1B* satellite, launched Oct. 31, 1962, by an *Able-Star.* The *SECOR* package comprised a CW transmitter, 162-324 mc, for geodetic measurements and 54-216 mc for refraction studies (M/R, Nov. 5, 1962, p. 15).

In operation, *SECOR* fixes ground positions through multiple-frequency phase comparison techniques. In a typical problem, simultaneous radio signals are sent to the satellite from three known stations and one or two unknown ones. By trigonometric means, the geodetic coordinates of the unknown stations can be determined without knowledge of the orbital parameters of the satellite.

The Army expects to reduce the error in locating land masses from one mile for continental areas and 5 to 10 miles for smaller areas, such as islands, to within about 100 ft. over a 1,000-mi. span.

Further launches of *SECOR* are expected, both as part of the *ANNA* program and independently in a *Thor-Agena.*

Serv-U Contracts Explained

Officials of both North American Aviation, Inc., and Northrop Corp. have testified that they signed vending machine contracts without knowing that Robert G. (Bobby) Baker, former secretary to the U.S. Senate majority, was a major stockholder in the company involved.

John L. Atwood, North American president, told the Senate Rules Committee last week that his firm was urged to alter its existing contract with another vending firm in January, 1962, and sign a contract with Serv-U Corp. by Fred B. Black, Jr., its Washington consultant.

He said NAA signed the new contract—which eventually was worth $2.5 million—because it offered a better commission from the vending machine operators to the company's employee welfare and recreation fund.

Robert R. Miller, senior vice president of Northrop, told a similar story. He testified that he was first approached by Black regarding the Serv-U deal, but did not know until recently that either Black or Baker was financially involved.

Von Braun Discusses Apollo

Space flight leaders hope to "man-rate" the *Saturn V* Moon rocket with two unmanned flights. Dr. Wernher von Braun, head of Marshall Space Flight Center, thinks five flights probably will be needed to prove the big *Saturn* safe for astronauts.

The first two flights will make heat shield tests at *Apollo* re-entry speeds, Dr. von Braun said. "We'll have to play it by ear after that," he told a press conference at the annual Space Fiesta at Texas A&M University in College Station, Tex.

Ten unmanned flights in Earth orbits appear likely before any attempt to land on the Moon, said *Apollo* boss George Low on a visit to the Manned Spacecraft Center in Houston. Dr. Low said he expects manned *Apollo* flights to begin in 1968 after unmanned launches starting in 1967. The firing rate will run four to six *Saturn V* shots per year, allowing two to three months between launches.

Von Braun said he expects to build 14 *Saturns.* He said the decreased time to man-rate the rocket stemmed from expectations that "all-up testing" would produce results faster. Under the plans presented to Congress last year, the seventh *Saturn* would have carried the first astronauts into Earth Orbit.

Von Braun's visit to Texas A&M may have turned up a boon for the Moon project.

The discovery is a device that uses the technique of "activation analysis" to identify all the elements present in a piece of soil. Its heart is a 5-in. atom smasher (linear accelerator) designed for nuclear bombs. The accelerator bombards a two-centimeter area with more than a billion neutrons per second at 600 bursts per second. This produces radioactive isotopes of the materials present in the soil. By scanning the spectrum of radioactivity resulting from this, a definite "fingerprint" for each element present can be established.

Dr. Richard Wainerdi, head of the Activation Analysis Research Laboratory (AARL) at Texas A&M, and chief engineer Lloyd Fite think they can package the instrument into a round "hatbox" package about 18 in. in diameter, 6 in. thick and weighing 30 lbs.

Cape Rail Strike Grinds on

The 13-month-old strike against the Florida East Coast Railway appeared as far as ever from settlement last week and a top U.S. Labor Dept. official renewed an earlier Federal recommendation that the railroad be barred from using Government-owned tracks at Cape Kennedy pending a settlement.

Assistant Labor Secretary James J. Reynolds sent the recommendation to Secretary Willard Wirtz after what he called "completely futile" talks with FEC board chairman Ed Ball in Daytona Beach. He blamed Ball and the Florida Railroad and Public Utilities Commission for the breakdown in negotiations between the company and the striking unions. Earlier, it was reported that the railroad president had walked out of the discussions with Reynolds.

Junction Box Foiled Athena

The first *Athena* missile, which was thrown 20 degrees off course after firing at Green River, Utah, Feb. 11 and impacted 200 miles from its target area, was victimized by short circuit in a second-stage junction box, Air Force sources indicated last week.

They said there was no connection between the malfunction and the *Athena's* guidance system or propulsion units.

Air Force Investigates Blast

A special Air Force board is investigating the recent *Atlas* explosion near Roswell, N.M. A fire set by the blast caused loss of $11 million.

The explosion occurred during a training exercise, but caused no injuries to crew members.

Shots of the Week

An official state (Antara) news agency report from Djakarta says that the Indonesian air force has launched a Soviet-built surface-to-air missile of the type thought to have brought down U.S. U-2 planes over Russia and Cuba. The firing was said to be part of a military alert in Indonesia connected with tension there over Malaysia.

- The Air Force on Feb. 15 launched from Vandenberg AFB, Calif., a secret satellite aboard a *Thor-Agena* rocket.
- An Air Force *Titan II* ICBM was successfully launched Feb. 17 from Vandenberg AFB, Calif. The 5,000-mi. shot was the ninth of 13 Category II test series firings. Launch was conducted by a SAC crew.
- A *Polaris A2* missile was successfully launched from the submarine USS James Monroe near Cape Kennedy, Fla., Feb. 17.
- NASA test pilot Milton Thompson flew the *X-15* Feb. 19 from Edward's AFB, Calif. Flight was third in a series to study heat transfer rates. The craft also carried equipment to measure boundary layer noise levels for possible use in the supersonic transport program.

Vinson Defends Missiles

Rep. Carl Vinson (D-Ga.), chairman of the House Armed Services Committee, said last week that "better informed" people, including top civilian and military officials, consider U.S. missiles "fully capable" of performing properly if needed.

The statement, made before the House Rules Committee, presently considering defense procurement and research authorizations, conflicted with statements made recently by Presidential aspirant Sen. Barry Goldwater that the U.S. missile deterent force is not reliable.

Beryllium Minuteman 'Spacer'

A new, all-beryllium inter-stage connector, to be used initially on Wing III versions of the *Minuteman* ICBM now in production, will shave about 23 lbs. off the front-end weight of the missile, providing increased range or warhead/penetration-aid carrying capability.

Production of the device, which structurally links the new Mark IIA re-entry vehicle with the missile's guidance and control section housing, reportedly marks the first full-scale production use of beryllium as a major structural component of an operating aerospace vehicle.

Announcement of a production contract in excess of $2 million by Avco. Corp., developers of the MK IIA, to the Brush Beryllium Co. of Cleveland for the connectors was made in New York last week. Delivery of production models has begun.

The connector, or "spacer," is a 32-in.-wide, 11-in.-deep cylinder with skin thickness tapering from 0.160 in. at its widest points to 0.080 in. at selected areas.

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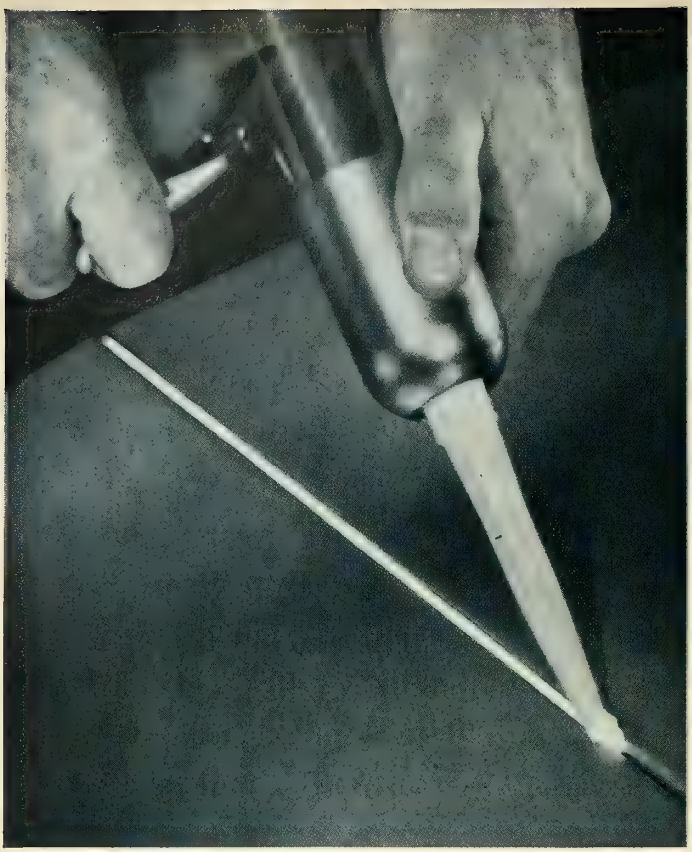
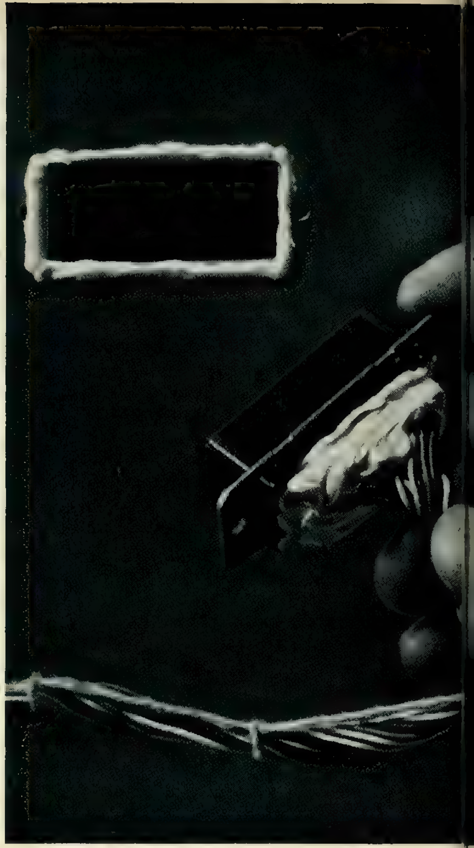
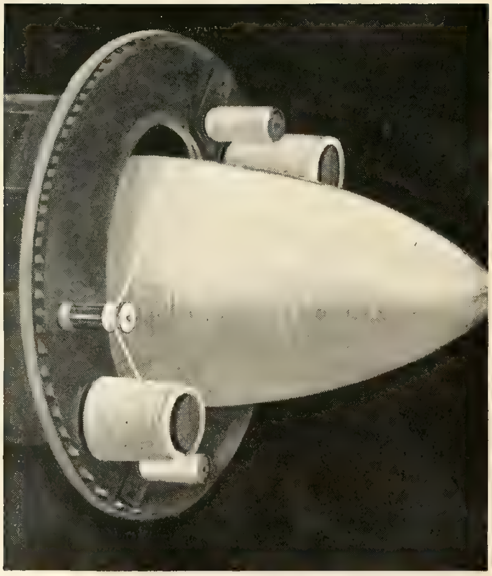




News Briefs



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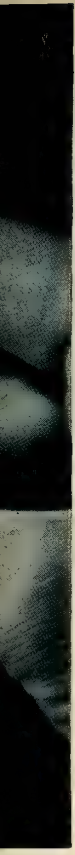

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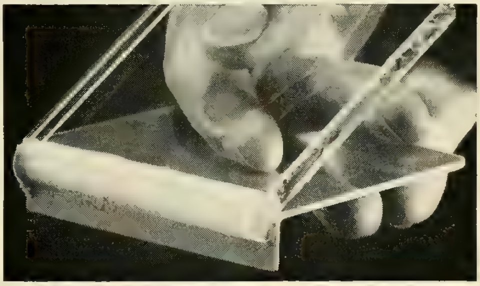

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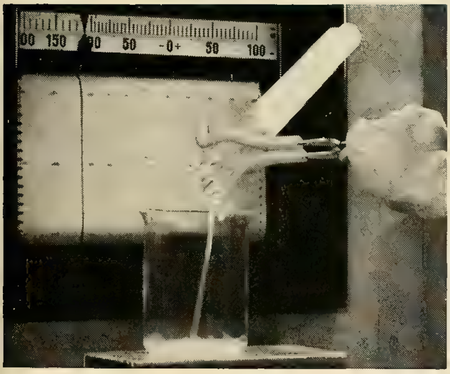

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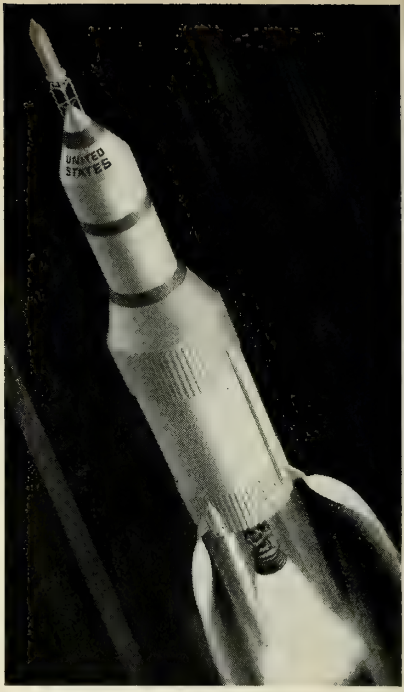
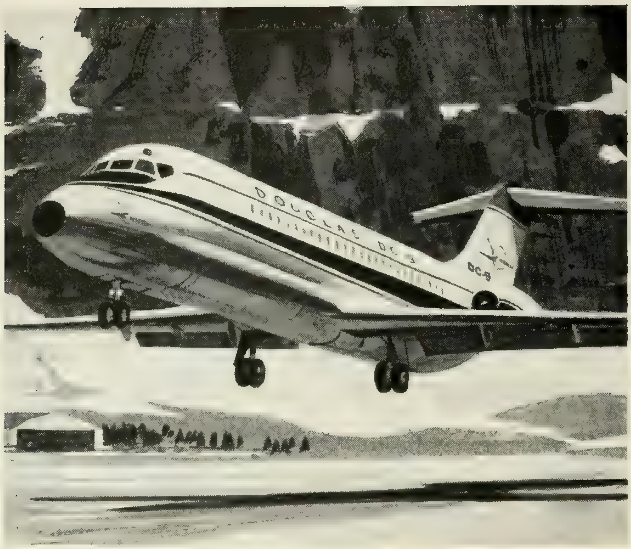
JETLINER—MOON LINER—SPACE CENTER

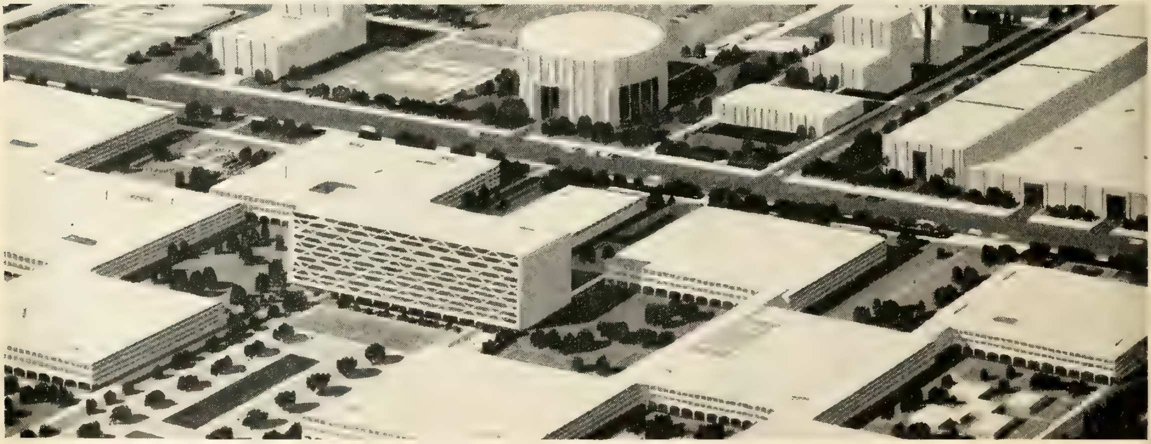
. . . on the rise



TO HELP PUT MAN ON THE MOON, *Saturn* S-IVB is being built by Douglas under direction of National Aeronautics and Space Administration's Marshall Space Flight Center. S-IVB is 58 feet tall and 22 feet in diameter. It will provide the thrust that will send 3 *Apollo* astronauts from earth orbit to moon orbit.



SIMPLICITY IS THE KEYNOTE of the reliability being built into the Douglas DC-9. The total number of components in its five major systems is far under that of other jetliners, with fewer wear points and faster and easier maintenance.



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To House subcommittee . . .

Brown Outlines 'Ultimate' MOL

DDR&E chief stresses current limitation to experimental lab, but says vehicle could eventually be assembled-in-orbit space station

by James Trainor

RENDEZVOUS, re-supply and orbital assembly into a space station are part of the "ultimate capability" of the Air Force's *Manned Orbiting Laboratory*.

This growth potential for *MOL* was revealed by Dr. Harold Brown in testimony before the House Armed Servics Research and Development subcommittee released last week.

The Defense Research and Engineering Director stressed, however, that this is only a capability and is not part of the present *MOL* program.

"I want to make a distinction between its ultimate capability and what is in the program" Brown said. "What is in the program is not a space station in that sense. It is an experimental laboratory. But . . . this could grow to be a space station, if and after . . . we conclude . . . that a man can have a substantial military purpose. . . ."

DOD is trying to avoid limiting the usefulness of *MOL* by building the experimental station around the experiments rather than as an afterthought, as was the case with *Dyna-Soar*.

• **Four immediate tasks**—During the next six months, the Air Force and DOD will make a detailed definition of the augmented *ASSET* program, *MOL*, the changes required in *Gemini-B* and the *Titan III-C/MOL/Gemini-B* interfaces, Dr. Albert C. Hall told a joint session of the Space Club and the Washington chapter of the Aviation/Space Writers Association. Hall is DDR&E deputy for space.

The augmented *ASSET* program is designed to collect data concerning severe re-entry conditions, and is expected to provide the technology for a possible ferry vehicle to support the *Manned Orbiting Laboratory*. Tests in the augmented program will include various re-entry body shapes, materials, structures and components.

Definition of *MOL* will be achieved by the *Orbiting Space Station* (*OSS*) contracts awarded to Douglas, GE and Martin, (M/R, Feb. 17, p. 15) and in-house studies.

• **MOL parameters**—General parameters for *MOL* were outlined by Dr. Brown in his testimony:

—A cylinder about 10 feet in diameter and 25 feet long weighing "well over 10,000 lbs."

—Double-walled to provide protection against meteorites, and divided into two pressurized compartments in case of meteorite penetration of one compartment.

—A third unpressurized compartment for vacuum component testing.

—A useful volume of 1,500 cubic feet and a useful payload, depending on the orbit, of 4,000-5,000 lbs.

Brown, however, then cautioned the committee that "until we can decide on the experiments we can't say in detail what this kind of thing would look like."

Modifications of *Gemini* to perform the *MOL* mission have not been finalized. The *"B"* is expected to weigh approxmiately 6,000 lbs. as opposed to 8,000 lbs. for the NASA capsule. The main area of weight saving will be in life support, since the only requirement for *Gemini-B* will be to sustain the pilots during the ascent and descent portions of the flight. NASA's *Gemini*, on the other hand, is required to sustain two astronauts for up to two weeks.

• **Experiments decisive**—With the question of man's utility in space still a matter of controversy, the experiments carried out in the *MOL* program are expected to have a decisive impact not only on the design of the laboratory itself but on future manned military operations as well.

Amply illustrating this point is Dr. Brown's statement that "at this point in time even the requirement for manned military operations is still in question." But the possibility that such operations may become important can't be ignored, and therefore the *MOL* program is being conducted.

Early answers regarding man's usefulness as well as design of future experiments are expected to come from the DOD experiments on NASA's *Gemini*. These packages are particularly important to the preliminary design and ultimate value of a co-orbital satellite inspection system. Separately funded, these experiments total $8 million in FY '64 and $6 million in FY '65.

"The missions to be emphasized are military," according to a DOD official, "and the experiments to evaluate man's role in military missions should be considered first." Other experiments, however, will also be considered—including, at a lower priority, non-military ones.

Bioastronautics experiments will be emphasized, particularly human factor measurements, tolerance to weightlessness, effect of movement on attitude stability and man's ability to control re-entry after 30 days in orbit. The crew's ability to adjust, maintain and repair equipment as well as their general visual ability, will also be evaluated.

Ground simulation and thorough study must precede any experimental effort in *MOL*, Defense officials emphasize. The non-orbital part of the program is a *sine qua non* and must be accorded proper emphasis and support, they point out.

NASA experiments involving manned use of equipment and instrumentation in orbit will also be included and will be accorded a priority exceeded only by military considerations. A DOD-NASA planning board, similar to the *Gemini* Program Planning Board, will also be set up to effect overall coordination of the program. ■

Definition in FY '65 . . .

McNamara Says DOD Is Pushing Polaris B3

Secretary 'anxious to see' results; highlights of other DOD testimony

PROJECT DEFINITION for the largest *Polaris* missiles that can be launched from submarines now under procurement will be conducted during FY 1965. Following definition, development of the propulsion system required for such a missile is to be initiated.

Describing himself as "anxious to see how much we can get out of this," Secretary of Defense Robert S. McNamara revealed that the Dept. of Defense is aggressively pursuing the *Polaris B3* program. The *B3*, as described by the Secretary, was essentially the same as outlined earlier in MISSILES AND ROCKETS (Jan. 13, p. 18).

"What it involves is the expansion of the missile within the existing hole, to utilize the hole more fully, and thereby to increase the range of the missile and/or the payload of the missile."

McNamara noted that *Polaris* submarines 6 through 18 would not be re-equipped with the *A3* missile but would keep the *A2*. One of the reasons he said, was that he wanted to consider the possibility of refitting a number of those vessels with the *B3* if it appears desirable.

The *B3* would exploit the maximum potential of the *Polaris* submarine and would take advantage of the fact that the Navy has reduced the six-inch liner in the missile tubes by several inches. Thus, the 54-in.-dia. limitation on the first three versions of *Polaris* could expand to 58 inches. New case materials and control systems could also be explored.

Secretary McNamara's statements were made before the House Armed Services Committee earlier this year and released just this week.

- **AADS-70 out of limbo**—The Army's Air Defense System for the 1970 time period (AADS-70) is expected to enter the component development stage during this year. The Army is presently evaluating requirements versus tradeoff studies conducted by three contractors —Hughes, Raytheon and RCA. Results of these studies are to be presented to the Army staff within the next few weeks.

From these studies, the critical components will be identified and, by the end of March, further work on these items could be authorized. Although only $5 million is included in the '65 budget for AADS-70, the total development cost would rival the combined cost of *Hawk* and *Hercules*. This is a serious drawback to ultimate development, but the cost could be reduced if the AADS-70 requirements were relaxed. This is something the Army is looking at now.

Other points covered by Defense witnesses included:

—In calendar 1965 some experience will be gained with the *Nike-X* Phased Array Radar and data-processing units as well as the *Sprint* missile. "That will be the earliest time at which a well-founded decision could be made on *Nike-X* deployment," according to Dr. Harold Brown, Director of Defense Research and Engineering.

—*Phoenix*, the air-to-air missile for the Navy's version of TFX, will begin prototype flight tests during FY '65. Wind tunnel tests and missile and control system mockups are now being completed.

- **Specific Cuts**—Further details of reductions in the authorization bill for procurement of aircraft, missiles and naval vessels and research and development were disclosed as the House Armed Services Committee reported the bill to Congress last week.

The net reduction of $270.5 million was entirely in the Research and Development section of the bill. Of that amount, the specific cuts made in R&D for missiles and space were:

Navy

—*Military Sciences:* $28.5 million, bringing the request down to $190 million. The Armed Services committee indicated that it objected to a 50% increase in management and support activities which it attributed to increased contract efforts with non-profit institutions.

—*Missiles:* $38 million, reducing the request to $376.5 million. The bill specifically deducted $5 million from the guided missile exploratory development program; $19 million from the $56-million request for *Tartar*, *Terrier*, and *Talos* and a new surface-to-air missile system; and cut $10 million in funds for the Pacific Missile Range. A $4 million cut was not identified.

—*Military Astronautics:* the full $33 million request was authorized.

Air Force

—*Military Sciences:* $9 million, reducing the request to the FY '64 level of $121 million.

—*Missiles:* $50 million, bringing the total to $806 million. The committee cut $35 million from a $110-million request for the *Mobile Medium Range Ballistic Missile* (*MMRBM*) (M/R, Feb. 17, p. 14) and $15 million from the *Advanced Ballistic Re-entry Systems* (*ABRES*) program and exploratory development on rocket propulsion.

—*Military Astronautics:* $37 million, reducing the total to $909.6 million. *Titan III* was cut back $20 million because of the cancellation of *Dyna-Soar* and "improved management techniques now being applied." Two other programs apparently were cut, but these were not specified by the committee. In addition, two programs, apparently classified, received additions of $3 million or more.

Army

—*Military Sciences:* $7.6 million, reducing the request to $146.6 million. The cut was aimed specifically at contract studies and analyses.

—*Missiles:* $15 million, bringing the total to $565 million. Missile exploratory development is decreased $5 million, while $10 million was cut from *Mauler* in view of its removal from the operational systems development category to the engineering development grouping.

—*Military Astronautics:* the $18 million requested for communications satellite terminals and participation in the *Syncom* program was approved by the committee *in toto*. ■

Late 1965 flight planned . . .

14 Experiments on First Biosatellite

FOURTEEN biological experiments will be flown in the first *Biosatellite* flight—scheduled for late 1965.

The initial experiments will be used to study the effects of radiation, weightlessness and the absence of the Earth's rotation on such specimens as pepper plants, wheat seedlings, amoeba, frog and sea urhcin eggs, bread mold, fruit flies and embryonic beetles.

The first *Biosatellite* flight with its 50 lbs. of experiments will last three days.

Five later flights will last from 21 to 30 days. Proposed experiments for those flights include some involving land and marine plants, roaches, rats, hamsters, human liver tissue cultures and primates.

The satellite is being developed for NASA by General Electric Co.'s Missile and Space Div. It will be launched from Cape Kennedy by the *Delta* booster and will be recovered in the Pacific Ocean.

• **170 experiments submitted**—The experiments for the first flight were selected by the space agency's Office of Space Sciences and Applications and the Office of Advanced Research and Technology from 170 proposals submitted to NASA.

The first experiment will measure during weightlessness the angle between leaf and stem of a pepper plant, which on Earth is controlled by certain hormones in the plant.

The second, third and fourth experiments will use the same group of wheat seedlings to determine whether: 1) weightlessness greatly affects the growth of roots and shoots of the seedlings; 2) weightlessness disrupts the normal orientation of cell division, and 3) seedlings growing in weightlessness are more sensitive to ionizing radiation.

The fifth experiment will attempt to detect the effect of weightlessness on the orderly division of nuclei in amoeba and on the evolution of food vacuoles—small cavities in cells filled with a liquid.

The sixth test will expose bread mold to radiation during weightlessness to determine whether it alters the biological effectiveness of the radiation.

• **Other first-flight tests**—Other experiments will:

—radiate flour beetle eggs during weightlessness to see if wing development is affected in the same degree as it is when identically radiated on Earth;

—study fertilized frog and sea urchin eggs to attempt to determine the effect of weightlessness on cell division, differentiation and growth.

—expose male wasps to radiation during weightlessness and mate them after recovery to determine whether weightlessness increases or decreases radiation effects on organisms.

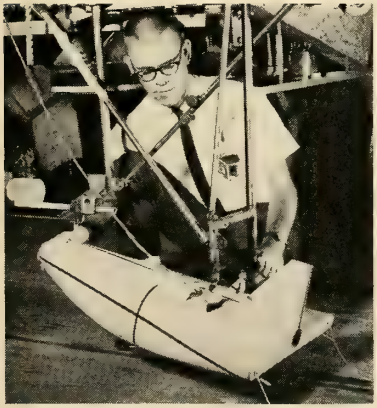
—study effects of radiation and weightlessness in tradescantia, a blue-flowering roadside plant, by observing cell color changes and cell death.

—test bacteria in which latent viruses begin to reproduce themselves at a known rate that increases when exposed to ionizing radiation. An attempt will be made to determine whether this process changes if the radiation takes place during weightlessness.

—expose adult fruit flies to radiation and weightlessness, and examine their offspring for genetic changes.

—expose immature (pupal stage) fruit flies to radiation under weightlessness to determine whole cell effects. ■

Space Agency Invites 29 Firms To Bid on Two Subsonic Lifting Body Gliders Based on M-2, HL-10



LANDING experiments being conducted at Langley with scale-model HL-10 vehicle.

NASA HAS INVITED 29 firms to submit proposals for the development of two lifting body gliders for a flight-test program beginning in 1965.

The gliders—based on the M-2 and HL-10 concepts studied by the Ames and Langley Research Centers—will be carried aloft under the wing of a B-52 and released at an altitude of 45,000 ft.

The 7,000 to 8,000-lb. vehicles, traveling at subsonic speeds, will be used in the space agency study of the problems of piloting advanced spacecraft during the landing phase.

Bids on the fixed-price contract have been requested from the firms within five weeks.

The lifting body research program is a cooperative effort of the Ames, Langley and Flight Research Centers for NASA's Office of Advanced Research and Technology. The centers are responsible for the research and test phases, while the selected contractor will be responsible for the structural design of the shell and control system of the gliders.

NASA will furnish the contractor information obtained through lifting-body research experiments on the M-2 concept at Ames and the HL-10 at Langley.

Both vehicles will be studied in the 40 x 80 ft. wind tunnel at Ames. After thorough testing and evaluation, the vehicles will then be investigated in flight at Flight Research Center, with Rogers Dry Lake as the landing area.

FY '65 fund request reveals . . .

NASA Construction Program Passes Peak

New facility money dropping sharply from previous levels with completion of installations needed for Project Apollo

by Hal Taylor

NASA'S FY '65 budget request makes it clear that funding for new facility construction will turn down sharply over the next few years.

Budget documents presented to Congress reveal that only about $50 million will be needed in future years to complete the projects included in the budget request.

Another major trend disclosed by the budget documents is that the cost of equipping the various new facilities now accounts for a much larger proportion of the total estimated cost than the actual construction of the buildings.

For example, of the $89.5 million requested for new facilities at Cape Kennedy, about $64 million will be used to purchase new equipment. The same trend is evident at the other major construction site, the Mississippi Test Facility.

The downward trend for NASA's construction program was first revealed by the drop from the FY '64 funding of $673.5 million to the FY '65 request of $281 million.

• **Apollo facilities key**—The downturn will be accentuated by the completion within the next fiscal year of funding for the major new facilities required by Project *Apollo* at Cape Kennedy, the Manned Spacecraft Center, the Mississippi Test Facility and Marshall Space Flight Center.

The only items in the FY '65 request to be funded in the future are the M-1 engine, $33 million; minor facilities at Cape Kennedy, $4 million; Wallops Station launch area modifications, $6.5 million; and several other minor projects.

NASA's future construction requirements are a cinch to exceed $50 million, however. Future budgets will be increased by additional facilities that are certain to be required at NASA's field centers.

Congressional cuts in the FY '65 budget would also mean higher money requests in the future by stretching out the building program.

• **ERC funding details**—Authorization of the proposed Electronics Research Center would also push the funding level higher. NASA estimates its total cost at $50 million, but thus far has asked Congress to approve only a little over $10 million. The highest funding rate for ERC is expected in FY '66.

The two major facilities planned for the Electronics Research Center in FY '65 include an electronic components laboratory, with a total request of $3.2 million, and the qualification and standards laboratory.

The component facility will be used for study, research and design of electrical components in the areas of solid-state technology, materials, vacuum devices and electro-mechanical componentry.

Almost $1.2 million of the total will be spent on the actual construction of the facility. Equipment for the laboratory will cost an additional $1.9 million, including component fabrication, $734,000; laboratory analytical equipment, $319,000; test equipment, $100,000; and glass technology equipment, $204,000.

Construction of the qualification and standards laboratory will cost $746,000.

• **Standards need explained**—The space agency told Congress the lab is necessary because it has experienced major difficulties in obtaining electronic components, subsystems and systems meeting the high standards of quality and reliability necessary for use in the space environment.

It further contended that costly redesign delays, flight failures and confusion and waste in the space electronics industry result from the lack of a common set of component specifications and standards.

The laboratory, it said, will handle component qualification testing, design criteria for electronics and guidance elements and component reliability engineering. About $2.2 million will be spent for special equipment for it.

The two other building items in the FY '65 budget request for the new research center are an engineering and administration building at a cost of $1.85 million and center support facilities at a cost of $1.95 million.

• **Higher equipment purchases**—The rising cost of equipping NASA's new facilities stems from the completion or near completion of the construction phase.

At Cape Kennedy, *Saturn V* launch complex No. 39 will be funded at a level of $63.2 million, but equipment costs will account for $57 million of the total.

Some of the items that will be purchased include propellant services, $23.4 million; communication, television and cabling, $6.6 million; firing accessories, $17.3 million; instrumentation, $5.8 million; and general support, $3.35 million.

There will also be high equipment costs at the Mississippi Test Facility. Of the $5.7 million requested for component service facilities, $3.2 million is earmarked for equipment purchases.

The *Saturn V* first-stage test stand has a project cost of $20.3 million in FY '65 with equipment costs estimated at $8.3 million.

Cost of the second-stage test stand is $20.5 million, with equipment requirements of $12 million. It includes instrumentation, control and communications systems, adaptation hardware, high-pressure water system, high-pressure gas system, helium cold gas system and stage checkout and storage system. ■

NASA Testifies That Rogallo Wing Is Probably Dead in Gemini Program

by Heather M. David

THE MUCH-TRUMPETED Rogallo wing paraglider is now almost definitely out of the *Gemini* program, unless a real need is established in Air Force studies now under way for NASA.

Manned spaceflight head Dr. George P. Mueller and *Gemini* director George M. Low told the House Manned Spaceflight Subcommittee chaired by Rep. Olin Teague (D-Tex.) the paraglider is not now a part of the *Gemini* schedule. Low admitted to the committee that present plans are that "all normal recoveries will be water."

The original plan for the *Gemini* series was that some land recoveries would be made with the use of the paraglider. The system is still in the development stage at North American Aviation, and is expected to be completed at about the time of the last two *Gemini* flights. However, Mueller said that "it will be available but not necessarily scheduled."

If the system proves itself "very well," Low said, it could be phased in for the last two flights. In addition, the unit would be used if the study now being pursued by the Air Force determines that a precision landing will be necessary.

- **Gemini research**—Fifteen experiments have been selected for early *Gemini* spaceflights and have been referred to the *Gemini* Program Planning Board.

Nineteen Dept. of Defense experiments are planned thus far, of which seven have been confirmed by technical feasibility studies. NASA has received proposals for 90 scientific experiments, and eight have been recommended to GPPB. Seven more have been chosen for further study.

Mueller, NASA's Manned Spaceflight Administrator, outlined these *Gemini* plans to the House Science and Astronautics Committee:

—*Flight No. 1*—March, 1964. An unmanned orbital flight—about 87-mile perigee and 161-mile apogee—to demonstrate the structural integrity of the spacecraft and launch vehicle, and make measurements of the launch vehicle. No recovery. Flight 1A can be flown if more flight information is needed.

—*Flight No. 2*—Summer, 1964. An unmanned, full systems test, on a ballistic trajectory with maximum altitude of 87 nautical miles. It should last about 19 minutes and have a range of 1,850 miles, and utilize water recovery.

—*Flight No. 3*—The first two-man flight. Three orbits, with controlled reentry. This flight may include NASA's Experiment No. POISE (Panel on Inflight Scientific Experiments) 74—Synergistic Effect of Radiation and Zero G on White Blood Cells, and POISE 80—Sea Urchin Egg Growth.

—*Flight No. 4*—Four-day manned flight, to investigate effects of prolonged spaceflight on the astronauts. Experiments may be: DOD 1: Visual definition of objects in space; DOD 8, visual definition of terrestrial features; DOD 11, radiation measurements; POISE 43, synoptic weather photography; POISE 92, synoptic terrain photography. Preliminary phases of extravehicular activity such as cabin depressurization and opening the hatch may also be investigated during this flight. Spacecraft is initially injected into 87-by-161-nautical mile orbit, then circularized at 161 nautical miles.

—*Flight No. 5*—Seven-day orbital flight at 161 nautical miles. Further effort in extravehicular activity and rendezvous evaluation exercises with the rendezvous pod (an *Agena D* boosted 24 hours earlier). Experiments planned are: DOD 4, passive infrared; DOD N-1, Astronaut visibility; and DOD 2 and 9 (classified). NASA experiments are POISE 41, visual acuity; POISE 42, cloud top altitude spectrometer; POISE 49, airglow horizon photography; POISE 12, zodiacal light photography.

Other experiments are being formulated by the Manned Spacecraft Center. Mueller also said that both NASA and DOD were interested in a series of autonomous navigation experiments to see how the astronauts perform with close control from the ground.

The House Space Committee, at a session chaired by Rep. Teague, closely questioned whether it was wise to have classified experiments in the *Gemini* program in view of their effect on international tracking station relations, and the general impression of the program. Mueller reported that DOD has agreed to declassify these experiments and will report them soon.

Gemini astronauts will be equipped with two-way voice communication, an oral thermometer, impedance pneumograph and a blood-pressure measuring system, Mueller said. A new miniature biomedical recording system has been developed and is now being integrated with an electro-encephalograph. In addition, work was begun on studying how to monitor extravehicular activity.

During Fiscal Year 1965 in the *Gemini* program, Mueller said, NASA will have six spacecraft delivered and four in production; four *Titan* launch vehicles delivered; one *Atlas* target launch vehicle delivered and four in production; one *Agena* target vehicle delivered and four in production.

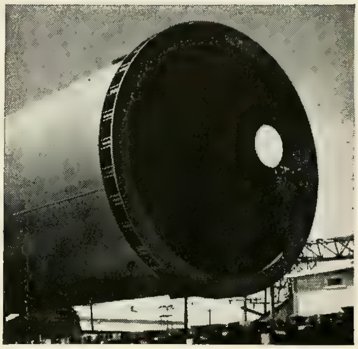
The Manned Spaceflight chief characterized the year 1963 as "quite frankly, one of development headaches," but said that the program is now largely over the development hump.

- **Apollo status**—During FY 1965, NASA will have six flight-configured spacecraft for ground test delivered, along with the last three developmental spacecraft; completed four production spacecraft for flight test; begun fabrication of 12 production spacecraft; delivered three lunar excursion modules for ground test; completed eight *Little Joe II* launch vehicles; launched *Saturn I SA-7, 8* and *9*; completed first *Saturn IB;* started fabrication of all stages for five *Saturn IB's* and fabricated *Saturn V* ground test and flight stages, and delivered first F-1 and J-2 flight engines.

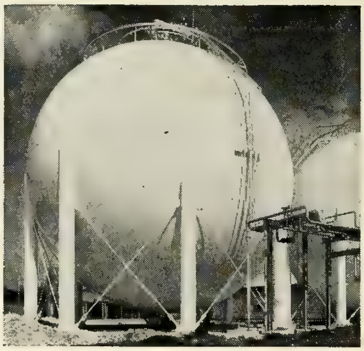
Mueller said that during the fiscal year four new F-1 engines would be built and 12 F-1 engines rebuilt to sustain the engine development test program. Seven new J-2's would be built and 14 rebuilt. ■

For the frozen frontiers: a family of steels to which zero means nothing

Strange things happen in the world of ultracold. Some metals get stronger bu sometimes so brittle they shatter like glass. Others become superconductor The load-carrying capacity of some fluctuates wildly. Material selection, in thi strange Pandora's Box world, must depend on carefully accumulated perform



This 56-ft.-long absorber unit is fabricated of A212 steel plate, popular for services requiring notch toughness down to —50F.



USS "T-1" Steel's excellent notch toughness, high strength, and weldability permit high working stresses in low temperature service.

This 2¼% nickel steel static altitude te chamber operates at temperatures rangin from —65F to 500F.

ASTM A201 and A212: for many years the only low-temperature steels available

These two carbon steel grades are widely used for a variety of applications requiring notch toughness down to —50F, such as refrigerated vessels for the storage of liquid propane or ammonia.

ASME allowable design stresses (¼ tensile) are 15,000 psi for A201 Grade B and 17,500 psi for A212 Grade B steels.

Both grades are available in flange or firebox qualities. When specified to meet the impact requirements of ASTM A300 to —50F, the plates may be furnished in the normalized or normalized and stress-relieved condition to meet the minimum requirements for the specific application.

This mark tells you a product is made of modern, dependable Steel.

USS "T-1" Steel: can cut pressure vessel weight up to 50%

USS "T-1" Steel combines great strength (100,000 psi min. yield strength), weldability, and low-temperature toughness (15 ft.-lb. min. Charpy keyhole at —50F). It is particularly suited for highly stressed pressure vessels operating at temperatures down to —50F, tank trucks for hauling LP gases, and welded lightweight structures.

Present allowable ASME stress for "T-1" Steel is 28,750 psi for plates up to 2" thick. In non-Code vessels, "T-1" Steel has been used at allowable stress levels as high as 50,000 psi.

In a series of dramatic burst tests, USS "T-1" Steel vessels withstood internal hydraulic pressures up to 2850 psi at about —45F before bursting, equivalent to a circumferential stress of 136,000 psi. Another series of "T-1" vessels, refrigerated to about —45F and pressurized to 1875 psi, were tested to destruction by impact from a 13-ton ingot dropped successively from 52, 73, and 101 feet. An impact energy of nearly 2,700,000 ft.-lbs. was required to rupture the vessel.

USS 2¼% Nickel Steel: down to —75F

2¼% nickel steel has been used widel for tanks, vessels, and piping handlin liquid propane and other liquefied gase at temperatures down to —75F. It ha been used particularly by the chemica industry for process and containmen vessels. Specialized uses include equip ment such as static altitude test cham bers operating at temperatures as lov as —65F to simulate 75,000 ft. heights

2¼% nickel steel is governed b ASTM A203, Grades A and B. Grade E is most widely used because of its allowable design stress of 17,500 psi compare to 16,250 psi for Grade A.

These steels are also covered b SA-203 of the ASME Boiler and Pressure Vessel Code.

nce data. We have a wealth of such data at United States Steel, plus compar-
tive design studies, that will make your material problems easier. Ask for a USS
ryogenics specialist by calling our nearest sales office, or writing United States
teel, Room 6835, 525 William Penn Place, Pittsburgh, Pennsylvania 15230.

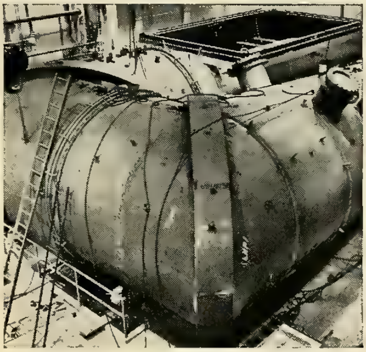
n-stress-relieved 9% nickel steel vessel
s refrigerated to —320F, pressurized to
ilure—at four times ASME allowable stress.
te ductile manner of failure.

SS 9% Nickel Steel: xcellent strength nd notch toughness own to –320F

eveloped, tested, and proven for cryo-
nic service, 9% nickel steel offers a
re combination of high yield strength,
ughness, and weldability. It is partic-
arly suited for large-tonnage oxygen
roducing equipment, and for the trans-
rtation and storage of liquid methane,
ygen, nitrogen, and argon. Because it
esn't require stress relief after fabri-
tion in most shell thicknesses, it is a
tural for large field erected tanks and
ssels.

The ASME allowable working stress
23,750 psi (Code Case 1308) is more
an double that of 10,000 psi permitted
e aluminum alloy 5083-0. Plate thick-
sses can be reduced to less than half
ose of aluminum with sizeable reduc-
ns in cost per square foot.

Where strength is vital, 9% nickel
eel is a natural alternate for alumi-
m. Its ease of fabrication results in
bstantial savings; data accumulated
date suggest savings of at least 10%
final erected cost compared to alumi-
m vessels.

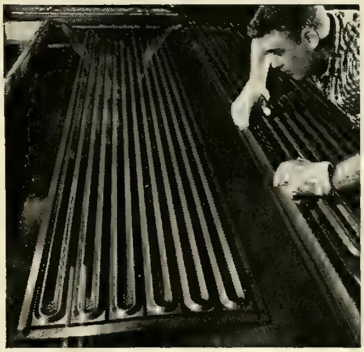


3½% nickel steel wind tunnel simulates, among other things, the frigid temperatures of altitudes up to 16 miles and over.

USS 3½% Nickel Steel: used for land-based facilities and ocean-going tankers

Low carbon 3½% nickel steel has been used for land-based facilities for the containment of liquid propane, carbon dioxide, acetylene, ethane, ethylene and other liquefied gases at temperatures down to —175F. Its excellent low-temperature toughness makes it suitable for use in shipboard tanks to transport liquid ethylene. Its formability, also excellent, has resulted in its use for tanks, vessels, piping, valves, fittings, heads, and many other components.

3½% nickel steel is covered by ASTM A203 Grades D and E. Allowable design stresses are 16,250 psi and 17,500 psi, respectively. These steels are covered under SA-203, ASME Boiler and Pressure Vessel Code.



Type 304 stainless coil heat exchanger retains strength, stability, and shock resistance in cryopump operating at —443F.

USS Type 304 Stainless Steel: the #1 cryogenic metal down to absolute zero

The austenitic chromium-nickel stainless steels, 304 and 304L, are by far the most popular metals for cryogenic service down as low as —459F. They are used widely in liquid oxygen production and storage, and the storage of liquid hydrogen and liquid helium. Wherever high purity is essential, such as handling liquid missile fuels, stainless is a must because its surface remains chemically clean and won't scale.

Type 304 stainless steel is easy to weld and fabricate, doesn't require stress relief after fabrication, and possesses high strength with excellent stability and shock resistance at very low temperatures. Its allowable design stress is 18,750 psi.

USS and "T-1" are registered trademarks.

USS **United States Steel**

At General Precision Aerospace this means "developing a TOTAL capability for COMPLETE aerospace vehicle systems." Throughout the last decade a large percentage of our in-house R&D and proposal efforts have been channeled in this direction.

It is easy to see that a target of these proportions is as valuable to the professional staff as it is to the company. It means technical breadth at state-of-art levels for the individual. It means growth in large system development and management for the organization with attendant broadening of sub-system and component capability.

Progress has been notable. The diversity of systems contract awards held by General Precision Aerospace confirm the company's position as developer and systems manager of complex and sophisticated defense and space programs.

A case in point is STAFF (Stellar Acquisition Feasibility Flight).

This is a new and comprehensive Flight Test Program for the USAF Ballistic Systems Division. The hybrid celestial-inertial guidance and control system to be tested was developed by engineers and scientists of General Precision Aerospace. The company is responsible for the guidance and control packages and the structural sections containing them. The packaged systems incorporate a Star Angle Comparator prototype. Forthcoming tests will provide data on the performance of the star tracker in the boost phase and also in the space environment.

KEEPING CREATIVE IDEAS "ON TARGET"

OPENINGS EXIST ON "STAFF" AND NEW APPLICATIONS OF THIS CONCEPT FOR OTHER ADVANCED AEROSPACE GUIDANCE PROGRAMS

Qualified professionals are invited to consider these openings at Intermediate and senior levels:

GUIDANCE SYSTEM ENGINEERING
Project management including servo loop analysis and design specifications for sub-systems such as stable platform, airborne digital computer, star tracker, and gyro performance requirements. Task will be in both terrestrial and celestial modes in connection with land and sea deployment.

FLIGHT CONTROL SYSTEMS ENGINEERING
Adaptive and optimal flight control systems analysis and design for mobile missile. Duties are concerned with aerodynamics stability, surface loading, re-entry energy management, control systems simulations and servo feed-back control techniques.

SYSTEMS DEFINITION AND INTEGRATION
Study and define performance requirements of variety of guidance and control sub-systems and establish criteria upon which interface specifications are prepared. Particular emphasis is given to systems analysis of special purpose airborne digital computer and programming.

FIELD FLIGHT TEST
Conduct on-site flight-testing of prototype stellar-inertial guidance systems. Requires field experience with knowledge of inertial guidance equipment. (Location is Cape Kennedy, Florida with training in Little Falls, N. J. to begin.)

TELEMETRY—INSTRUMENTATION
Plan and design airborne missile PCM telemetry and data reduction instrumentation systems for flight test programs. Direct experience in FM/FM telemetry ground station operation and data reduction required.

FLIGHT TEST ANALYSIS
Create and design flight and sled test programs for ballistic missiles and analyze system performance data.

ELECTRO-OPTICAL
Design and analysis of electro-optical instruments for integration in stellar-inertial guidance systems. Requires knowledge of astro-sensors in digital data handling and signal processing devices.

FLOATED GYROS
D&D of floated rate, integrating rate, airbearing gyros for use in inertial navigation systems for missiles and space vehicles utilizing fluid and gas dynamics techniques.

INERTIAL PLATFORMS
D&D of advanced inertial platforms for use in navigation systems for missiles and space vehicles.

ELECTRONICS SYSTEMS
Management position for engineering projects in areas of transistorized AC & DC computer circuits; high accuracy feedback amplifier design; operational amplifiers; analog computer and instrumentation system organization and design. A strong background in circuit and feed-back control essential.

ENGINEERING ANALYSIS & DESIGN
Analysis & design of advanced platforms, accelerometers and gyro packages. Experience in thermal, stress, or vibration analysis for advanced stable platforms and reference sub-systems. Background in stability and error analysis as well as servo amplifier and loop analysis.

ANALOG-DIGITAL CONVERSION & COMPUTATION
Analysis and design of all electronic solid-state A/D and D/A converters; digital integrators, and hybrid computing equipment. Strong advanced circuit background necessary with knowledge in system analysis, digital logic, precision pulse generation and switching, multiplexers, digital and analog storage techniques, high speed sampling & sampled data theory.

RESEARCH ENGINEER—GYRODYNAMICS
To develop advanced inertial devices. Requires a strong theoretical background in analytical mechanics and servo theory. MS-ME or Physics with 8-10 years' experience in acoustics, fluid mechanics and device technology.

ELECTRONIC CONTROLS AND INSTRUMENTATION
Design and application of closed servo loop control systems and instrumentation networks for testing procedures for extreme environments of advanced inertial navigation systems.

DIGITAL SYSTEMS ENGINEERING
System application and utilization of real time airborne digital computers for stellar-inertial guidance systems. Major technical task responsibilities in preliminary digital computer logic and circuit design. Evaluation of computer development and vendor technical techniques.

ADDITIONAL OPENINGS IN SUCH AREAS AS:

SYSTEMS ANALYSIS / ADVANCED PROGRAMS — PROGRAM MANAGERS AND SENIOR STAFF ENGINEERS / SCIENTIFIC PROGRAMMERS — COMPUTATION

Write Val Metelsky at General Precision Aerospace, Dept. 13-H, 1150 McBride Avenue, Little Falls, New Jersey.

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Technical Countdown

ELECTRONICS

IBM Perfects Laser Amplifier

An experimental gallium arsenide device has amplified laser signals more than 1,000 times their original strength in lab demonstrations at IBM's Federal Systems Div. The amplifier, as described in the current Applied Physics Letters, amplifies and filters a beam from an injection laser light source. The device will now permit detection of laser signals with simple heterodyne equipment. The frequency of the narrower laser spectrum is more stable. The relatively noise-free amplifier can replace photomultiplier tubes used as light detectors in laser experiments.

Thermal Plots of Integrated Circuits Derived

To aid circuit designers, a technique for computing temperature distributions in integrated circuits, using an IBM 7094, has been developed at Autonetics, a division of North American Aviation. The active surface of a chip is resolved to about 0.002 in., and the simulation provides temperature data on 11,000 points in one circuit. About 100 punched cards specify the electrical and geometric characteristics of the active surface. Isotherm drawings displayed on a cathode ray tube is one form of output available.

TIMMS Function Through Neutron Blast

A linear ac amplifier made up of General Electric Thermionic Integrated Micro Modules (TIMMs) functioned through a burst of 10^{18} nvt at 10^{7} R/sec. in the Sandia Pulsed Reactor Facility with only a slight negative dc shift near the peak of the burst. Test signal through the amplifier was a 100-kc sine wave. Made up of 6 triodes, 8 diodes and 19 resistors, the amplifier recovered completely 60 microseconds after the burst. J. Hannabach and D. D. Mickey of GE predict reliable circuit performance for the TIMM concept up to 10^{18} nvt. They say one company with a radiation-hardened computer contract from the Air Force is considering use of TIMM devices at levels between 10^{19} and 10^{21} nvt.

Electro-Optical Monitor Delivered

A three-axis electro-optical monitoring system developed by Chrysler Corp. Missile Division has been turned over to the Navy's BuShips. The classified instrument measures rotation about three orthogonal axes with one light beam to an accuracy of one arc second. Aimed at continuous alignment and other metrology functions, the high homogeniety of the light beam allows lateral movement of the monitored subject without affecting accuracy. The device's angular range is independent of distance, and it does not use the movement of an image to measure rotation.

Green Laser Set For Underwater Work

A coherent green light source perfected by the Laser Systems Center of Lear Siegler will be used by researchers at the Naval Ordnance Lab, Silver Spring, Md., for underwater and photochemical experiments. Present red light laser systems are not as applicable to underwater activities as the green light. The green light is generated by projecting an output beam from a neodymium-doped glass laser into a non-linear crystalline material. The second harmonic of the laser output is physically generated within the crystal with a conversion efficiency of better than 20%. Beam width is approximately 1 milliradian. More than 100 kw of coherent radiation with a bandwidth of 10 angstroms centered at 5,300 angstroms has been observed.

IC Radiation Sensitivity Related to Complexity

Complex integrated circuits are more sensitive to gamma radiation than simple integrated circuits, report R. W. Marshall and E. P. Mitchell, Nucleonics division, Hughes Aircraft Co., Fullerton, Calif. Some circuits are susceptible to doses as low as 10^{6} R/sec. Thin-film active devices are not affected by dose rates of 10^{8} R/sec., they say, predicting that such devices will be available for nuclear radiation applications within one or two years.

MATERIALS

Giant Quantum Effect in Superconductivity

Ford Motor Co. scientists report observing a macroscopic quantum system formed by the interference between wavelike properties of electrons flowing between two superconductors. The system obeys the laws of quantum theory but it extends over a distance of 3.5 mm—a rare effect. The wave properties interfere with each other constructively and destructively, resulting in current fluctuations. The Ford work is the first experimental verification of the theoretical picture of superconductivity being a single quantum state of very large extent postulated by the late Prof. Fritz London 20 years ago. The effect may produce a whole new family of solid-state devices. A current amplifier has already been constructed by Ford scientists at the company's scientific lab at Dearborn, Mich.

Irish Silica Hits Market

A new green silica insulation material—"Irish" Refrasil—extends the silica fiber heat range significantly, say its developers at H. I. Thomspon Fiber Glass Co. The green and regular Refrasil materials have essentially the same physical properties, but the Irish cousin can handle 2,800° F for prolonged periods, has a reduced char rate and shows improved resin absorption and wetting-out characteristics. Irish Refrasil is available in limited quantity lots of cloth, batt, random fiber, cordage, yarn and sleevings.

Gelatin Studied as Rigidizing Agent

The Aeronautical Systems Division's Aero-Propulsion and Materials Laboratories at Wright-Patterson AFB are looking at gelatin as a rigidizing substance for space materials. ASD found that it has a tensile strength of 17,000 to 21,000 psi for films 40 mils thick, comparing favorably to the highest strength plastic. When combined with fiberglass cloth, it has flexural strength as high as 80,000 psi. In a recent test, ASD engineers produced a pyramid of fiberglass cloth layers impregnated with gelatin, and hydraulically pressed at approximately 150 psi. Permanent antifreeze, which had been used as a plasticizer, evaporated in the vacuum chamber and the pyramid became rigid at 150,000 ft. altitude.

Acceptance Testing Under Way On Honeywell Apollo Flight Display Unit

by Charles D. LaFond

THE *APOLLO* all-attitude flight-display prototype is undergoing acceptance testing at Honeywell's Military Products facility in Minneapolis, Minn. The 11.9-lb. instrument provides integrated displays covering seven spacecraft operating modes.

Contained in a 7 x 7⅜ x 9⅞ in. case, the Flight Director Attitude Indicator (FDAI) will monitor the guidance and navigation system and provide G&N backup for manned maneuvers through the stabilization and control system.

Several prototypes have been built by Honeywell as a part of its *Apollo* stabilization and control for North American Aviation's Space and Information Systems Division. Design for the FDAI has been accepted and production models are being built.

Prototypes are expected to undergo environmental testing early this spring.

Honeywell's FDAI, designers disclosed, while not the ideal configuration, does represent the closest practicable approximation of all requirements imposed by human engineering on such an indicator. With minimum compromise on reliability and power consumption, it was designed as a fully integrated system within the constraints imposed by mechanical, electrical and signal interface limitations.

- **Functionally related**—The FDAI will be activated during the *Apollo* launch phase in a monitor mode. Following launch, the display will be able to present the pilot "all the parameters necessary to visualize the spacecraft's orientation in space with respect to a meaningful reference frame," according to one Honeywell spokesman.

All nine indicators are independently operated and energized, but all are functionally related. In short, they will permit the spacecraft pilot to determine the control response required directly, and thus perform or observe spatial attitude changes without transformation from display to control.

The seven operating modes (of the spacecraft) include 1) G&N attitude control, 2) stabilization and control system (SCS) attitude control, 3) SCS local vertical, 4) G&N, 5) delta V (velocity change), 6) G&N and 7) SCS entry.

Automatic attitude-control functions of the G&N or SCS are displayed for monitoring purposes in each of the modes. Also, all the information necessary to assist in performing manual control of spacecraft attitude is presented continuously.

- **FDAI indicators**—Nine indicators are provided by the FDAI: a 4½-in. diameter gimbaled plastic sphere that shows whole-angle attitude in euler angles in three mutually perpendicular axes (with respect to a specific frame of reference); three attitude-deviation pointers providing vehicular attitude error, and command attitude in magnitude and direction in each perpendicular plane (aligned in either spacecraft body or stability axes); and three attitude rate indicators. The latter display vehicle angular velocity about each perpendicular axis, aligned either in a spacecraft body or pseudo-stability reference-frame configuration.

The small sphere in the display symbolically represents the spacecraft's orientation with respect to whatever space-stable reference is selected (such as the plane of the ecliptic).

On the transparent faceplate in front of the ball, two index marks are superimposed representing the vehicle's body and navigation axes.

The *Apollo* Command Module, because of its design, will be pitched down 32 degrees during atmospheric reentry. Therefore, during this operating period, the body axis index will be located 32 degrees below the navigation-axis index.

As a graphic aid, the upper hemisphere of the sphere is white, the lower black to indicate plus or minus elevation. The yaw angle range extends from ±90 degrees to −90 degrees; pitch and roll angles vary from 0 to 360 degrees.

Heading values (with the white hemisphere in the top position), printed on the surface of the sphere, increase to the right. Roll values are printed on the rim of the case about the sphere, increasing counterclockwise.

Red areas on the sphere indicate dangerous maneuvers—such that gimbal lock of the stable platform might occur.

The attitude deviation indicator needles give a positive indication of the maneuvers required (to zero the needles).

- **Background**—In the summer of 1957, Honeywell recommended that a study for an integrated flight attitude indicator be conducted for the *Apollo* program. At that time, the firm's engineers had outlined those attributes of ideal spacecraft orientation display. These included the ability:

1) to interpret directly and readily visualize orientation in space with respect to a reference system having real meaning to the pilot;

2) to determine directly control responses required to achieve orientation changes with no required information transformation from display to control;

3) to shift attention from element to element within the display or from the display as a whole to other displays without requiring a change of set in direction-of-motion interpretation, reference index interpretation or scale change interpretation;

4) to operate in the frame-of-reference of all related equipment without changing set;

5) to determine the status of and monitor the system-orientation-sensing equipment;

6) to easily read and interpret the display at any orientation;

7) to capitalize on population stereotypes and past-training biases for configuration and direction-of-motion relationships.

• **Automatic, manual data similar**—Past experience with operator-controlled attitude systems, according to Honeywell, has indicated that the data needs for manually operated systems are similar to the information an automatic control system requires in doing the similar task—that is, the instrument displays used by a pilot in flying contain primarily the same information used by an autopilot. The summed output of an autopilot bridge or channel provides the basis for a good signal for a "quickened" display.

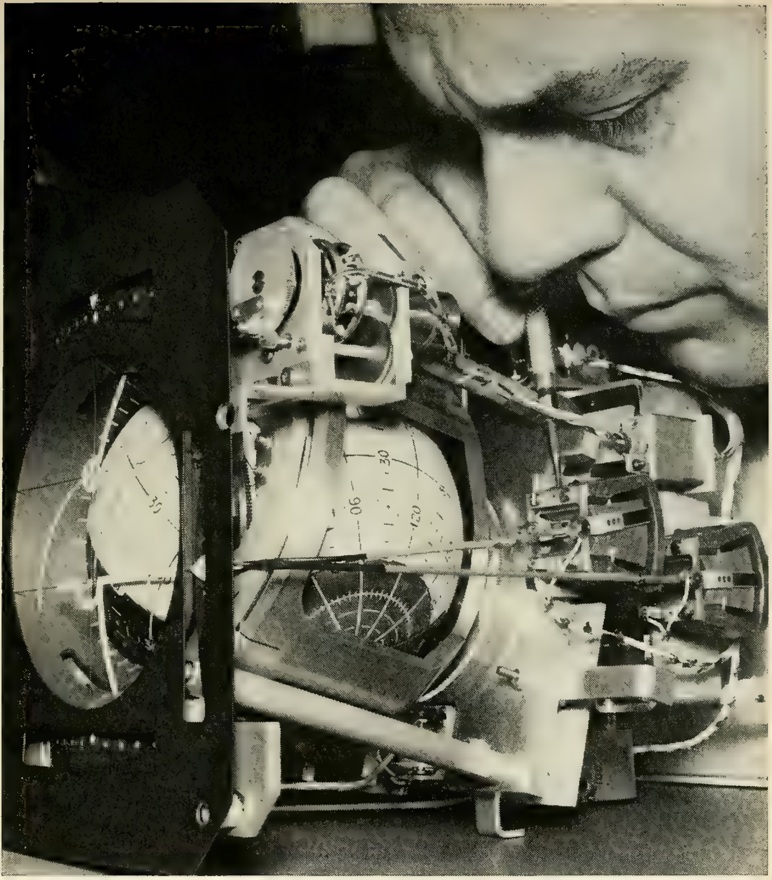
The pilot provides his own shaping, gain and application logic to the information before he actuates his controls. Man can also substitute informational sources and cross check elements for consistency. When man is controlling the system directly, the nature of the display-control relationships plays a major role provided the necessary information is present and the system is within the operator's control bandwidth.

In monitoring an automatic function, the astronaut is interested less in the elements requiring control actions than in the overall consistency of the system signals. He will be evaluating the information to make the decision to take over manually, to stop an operation or to continue automatically. In such a case, the cross-check of the error signal and the attitude provides for evaluating the SCS operation and the system logic. A cross-check of the vehicle rate and attitude provides information for evaluating the reference systems.

Experience and numerous studies have grouped space vehicle attitude requirements into three categories; attitude, attitude rate and attitude command or deviation from a desired attitude. As these elements usually are blended by an automatic control system to produce a control signal, so the information must be blended by the astronaut via his visual and mental organizational capabilities.

The basic consideration in man's case involves the question of whether the man can interpret the information to introduce his decisions and inputs into the system correctly and within time.

• **Apollo concept**—The analysis of requirements and investigation of the Apollo system's expected performance brought Honeywell to the position that the *Mercury* vehicle rate-attitude concept was inadequate for *Apollo*, and a new display concept was defined. The new display concept is not a radical change but does differ from previous attitude indication systems.



APOLLO Flight Director Attitude Indicator (FDAI) monitors guidance and navigation system and provides G&N backup through stabilization and control system.

Honeywell determined the *Apollo* mission would require a pictorial presentation. The principles governing the choice of the primary attitude indicator for *Apollo* were:

1) It must provide adequate information necessary to allow the astronaut to control vehicle attitude in all manual modes.

2) It must provide means of monitoring the adequacy of automatic SCS operation and allow a simple transition to manual or semi-automatic operations.

3) It must be capable of allowing the astronaut to check the condition of primary reference system and related equipment.

4) The display concept chosen must be capable of meeting the specified *Apollo* environmental conditions and delivery schedule.

5) It should be compatible with current operational procedures in high-performance aircraft.

6) It should assist the astronaut to minimize fuel consumption.

7) It should be flexible enough to allow the astronaut to control to varied degrees of accuracy and modes of operation.

The display system should be capable of handling anticipated changes in requirements as well as the presently defined operating envelope.

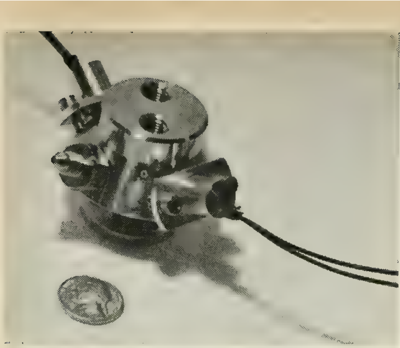
8) It should be acceptable to the general using public.

A NASA study of retrograde firing using the three-axis-ball and a *Mercury*-type rate-attitude indicator showed that pilots did better with the three-axis-ball and preferred it.

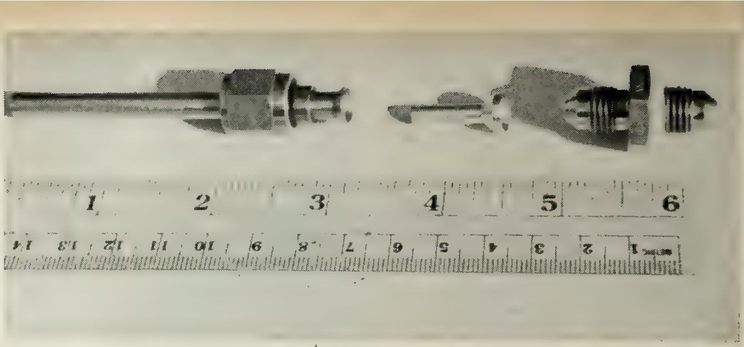
• **More demanding than Mercury**—The *Mercury* attitude-rate indicator was just "adequate" for a reduced requirement that was very precisely defined.

Not only is the *Apollo* vehicle mission changing in nature and requirement, but it already has manual modes more stringent than *Mercury*.

When employed with the *Apollo* SCS, the FDAI will help monitor the stabilization and control system execution of guidance and navigation system commands and aid manual execution in the event of most SCS failures. ■



MICROMOTOR injector built by Fox Valve, complete except for nozzle.



EXPLODED VIEW shows installation of line insert-type, fixed-area venturi in a standard flared tube connection. The unit fits directly in the line.

space support

Venturis Offer Test Stand Flexibility

Cavitating venturis can regulate engine thrust by 50:1 factor, serve as flow measure check

by John F. Judge

A series of commercially available cavitating venturis is providing a new high in flexibility for rocket testing facilities.

Developed to customer specifications by the Fox Valve Development Co., variable geometry cavitating venturis have demonstrated an ability to vary flow—and therefore thrust—well over 50:1 range with fairly low energy losses.

These venturis, says Zola Fox, president of the firm, impart into every test stand an automatic check on flow measuring equipment, act as a flow limiter in event of a major failure, and control the flow rate and mixture ratio during start-up transients.

The devices even tend to reduce tolerance requirements of pressurizing tank regulators.

A cavitating venturi is a venturi-shaped passageway in which the throat area has been reduced such that the velocity head at the throat equals the total pressure head. Under these circumstances, fluid passing through the throat flashes into vapor at the fluid vapor pressure. Recondensation of the fluid takes place in the divergent section of the venturi with accompanying deceleration of the fluid.

• **No surface erosion**—The word cavitation is something of a misnomer as applied to a cavitating venturi. Loss of surface material such as occurs in rotating equipment under "cavitating" conditions does not take place in a cavitating venturi. Fox Valve has pioneered use of cavitating venturis in cryogenics, liquid metals, slurries and corrosive media. In these applications, surface erosion has not been noticeably accelerated by the cavitation phenomena.

A cavitating venturi can be equated, within a given flow system, to a fixed area orifice exposed to a known upstream pressure and a fixed downstream (vapor) pressure. Hence, for a venturi of known throat area and a given fluid, only one flow rate is possible for any condition of feed pressure. Thus, the cavitating venturi can be used as a flow regulator by simply controlling feed pressure. Or it can serve as a flow meter if the feed pressure is recorded.

Maintenance of vaporization at the throat depends on downstream conditions and the recovery efficiency of the venturi diffuser. Fox cavitating venturis have a recovery efficiency of 85 to 92%.

This means that if one of these venturis is installed in a 1,000-psi supply line, pressure restriction downstream of the venturi can be varied from vapor pressure of the fluid (usually negligible) to 850-920 psi with absolutely no variation in flow. Note that the pressure drop through the venturi is a minimum of 8 to 15% of the inlet pressure.

The stablilizing influence and flow metering characteristics of such a device in feeding any sort of reaction chamber is obvious. Perturbations in reaction chamber pressures cannot be reflected into the feed system. The venturi acts as sort of a choke, damping oscillations and yet continually controlling flow.

Flow rates during transient start-ups cannot exceed rated design flow even though reaction chamber pressures are momentarily off design values. Even small oscillations in feed pressure are reduced in importance inasmuch as system flow is dictated by the square root of feed pressures minus vapor pressure —a large number—rather than a numerically small differential pressure.

A cavitating venturi is not senstive to gas slugging as are other flow meters used in the handling of low density cryogenic media. Quick flow measurement of even liquid metals is possible without elaborate instrumentation. An extensive research program recently conducted by Fox Valve has proven the utility of these devices even with gelled slurries having solidity in excess of 80%.

• **Operation**—Variation in the throat area of a cavitating venturi is accomplished by inserting a needle-shaped pintle into the venturi throat. The effective area of the venturi is an annulus instead of a circular passageway. The pintle is either threaded into the housing for manual adjustment of area or is motivated axially by a remotely operated actuator. Pintle position in a manually operated adjustable

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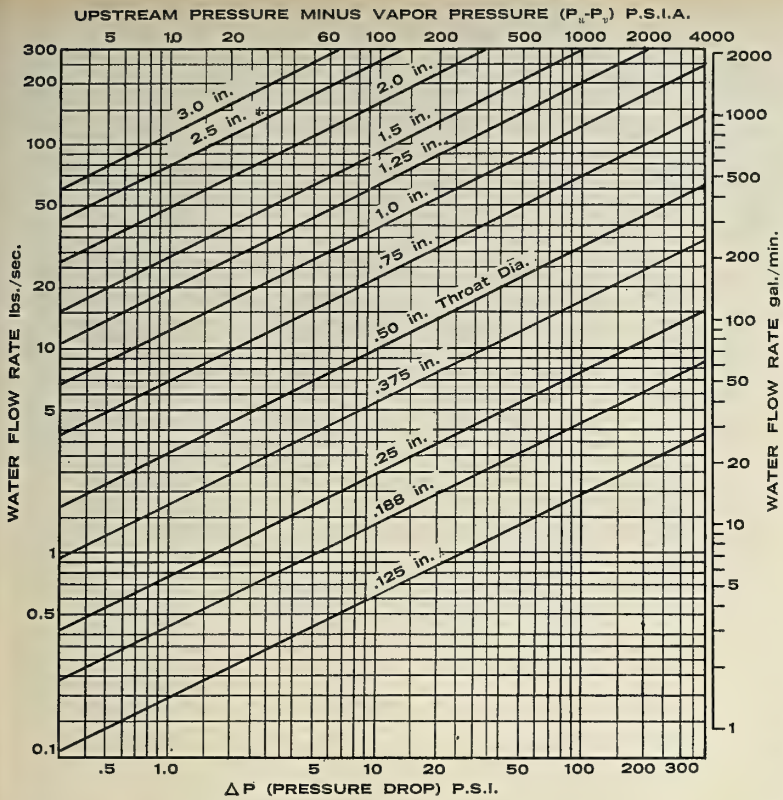


PRESSURE DROP and cavitation characteristics of Fox venturi valves.

area venturi is readily established externally by use of a micrometer. Remote operated units require a potentiometer or other electrical position indicator.

Prior to installation, the adjustable venturi is carefully water-flow calibrated over the full range of pintle positions. Water-flow data is readily converted to any propellant.

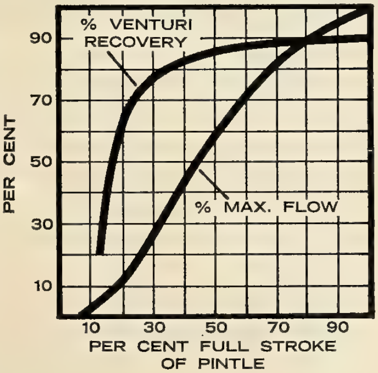
In rocketry, adjustable area venturies have two outstanding applications. The most frequent application to date has been on the rocket test stand. The upcoming host of applications concerns throttling rocket engines of wide flow rangeability.

In test stand use, the adjustable area venturi is usually installed semi-permanentiy downstream from the main propellant (test stand) supply valve. When a given rocket engine is installed, the pintle is preset to maintain desired flow rate at the specified feed pressure.

The venturi serves to check flow meter readings and will limit flow rate to nominal values. Injector pressure drop, uncertainties in engine performance and other variables will not preclude operation at desired flow and mixture ratio levels.

A remote operated adjustable area venturi for throttling engines is a "hard" flow controller. Once set, it will maintain thrust level constant. When linked so both oxidizer and fuel units are motivated in unison, positive mixture ratio over a full thrust range can be achieved. Many throttling adjustable area venturies are in development covering both large and small variable thrust engines.

Fox cavitating venturis have no moving parts—unless adjustable—and can be fabricated from any machineable material. There are no known limits of application, says Fox, and the devices have been used in both cyrogenic and liquid metal areas. Current cavitating venturis are being made with throat sizes ranging from 0.0135 to 4 in.



VARIATION IN flow rate and venturi performance as function of pintle position.

- **Valving applications**—Cavitating venturis as developed by the firm offer unique advantages to propellant flow control problems in aerospace technology, says Fox.

Once systems planners recognize the merits of these devices, he adds, further engineering advantages accrue. A cavitating venturi represents the smallest possible aperture in a fluid flow system.

If the flow system requires a shut-off valve, the logical point for this would be at the venturi. Fox says a 1.5-in. line having a cavitating venturi with a throat diameter of about 0.25 in. may be opened and closed with a 0.25-in. valve, an 8-in. line may be opened and closed with a 2.5-in. valve, and a small 0.25-in. line size attitude control valve may operate with a valve normally used to open and close a 0.25-in. orifice.

Drastic weight savings, improvements in reliability, reduction in leakage potential and power requirements are realized.

Fox-designed venturi valves have proven adaptable to various special requirements. The concept lends itself to relief valving, sequencing and disconnect valving.

The valve consists of a pilot-operated shut-off valve seating at the throat of a carefully contoured venturi section. Line pressure itself is used to actuate the valve open or closed. A single, small electrical solenoid or toggle-type manual valve is sufficient to pilot valves at extremely high pressures.

The design eliminates actuating shafts, rods and bellows extending through the outside wall of the valve—making the unit ideal for any type of jacketing. The maximum outer diameter of the Fox valve is practically the same as the line size. The major portion of the valve is actually smaller than line size. The need for an efficient diffuser makes the Fox valve somewhat longer than other types of valves.

The basic valve consists of a convergent-divergent passageway with a simple, spring-loaded poppet seated at the venturi throat. Pressure applied at the valve inlet exterts a seating force on the poppet in the same direction as the spring—assuring complete valve closure and effective sealing.

The sealing capabilities of the Fox Venturi valve result from the small size of the seat relative to line size and the simple, self-aligning poppet. In addition, there is no relative rotation of seating surfaces—eliminating abrasion.

Since the moving parts of the valve are relatively small and light, rapid response is readily obtained. Response, says Fox, is a function of operating pressure-throat contraction ratio. ■

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DR. SAENGER in exclusive interview.

Saenger's Final Interview with M/R

by William Beller

Last summer, MISSILES AND ROCKETS *interviewed Dr. Eugen Saenger at his university office in West Berlin. He was then professor of astronautics at the Technical University of Berlin, a post he assumed in March, 1963. We asked about his current research on recoverable launch vehicles and about the role he played in Egyptian rocket development. This article, based on the interview, was delayed pending Dr. Saenger's sending some technical data and photographs about his steam-rocket launcher. Dr. Saenger died early this month. Thus we publish what were probably his last words to the press about some of the problems of astronautics, about an aerospace plane and about his beliefs concerning Egyptian rocketry and the men behind it.*

WEST BERLIN—During World War II, Dr. Saenger and Dr. Irene Bredt, a mathematician who later married Dr. Saenger, wrote a lengthy report for the German High Command recommending development of an antipodal bomber. It was to skip halfway around the Earth on the upper fringes of the Earth's atmosphere—traveling like a flat stone skimming across the surface of a lake.

The proposed airplane was to be ground-launched by a rocket-powered sled that would catapult the bomber into the air at 500 meters per second, achieved at the end of a straight 2-kilometer track.

When Saenger submitted the report, the military situation in Germany was too desperate for the idea to be considered. Classified "State Secret," it reached allied hands after the war.

- **Soviet kidnap fails**—The Soviets, intrigued by the idea of a round-the-world bomber, sought to kidnap Saenger, but the agents selected to do the job—one of whom was Stalin's son—seemingly were more interested in Saenger's domicile, Paris, than in the scientist.

The United States later adopted Saenger's aerodynamic ideas—for the design of the *Dyna-Soar*. However, the rocket-sled launch was replaced by a *Titan III* booster.

At the time of the Saenger interview, the U.S. Department of Defense was considering cancelling the *Dyna-Soar* program. Saenger said he was "upset there is so much discussion in your country concerning the scientific and technical significance of *Dyna-Soar*. We consider development of such a craft of tremendous importance."

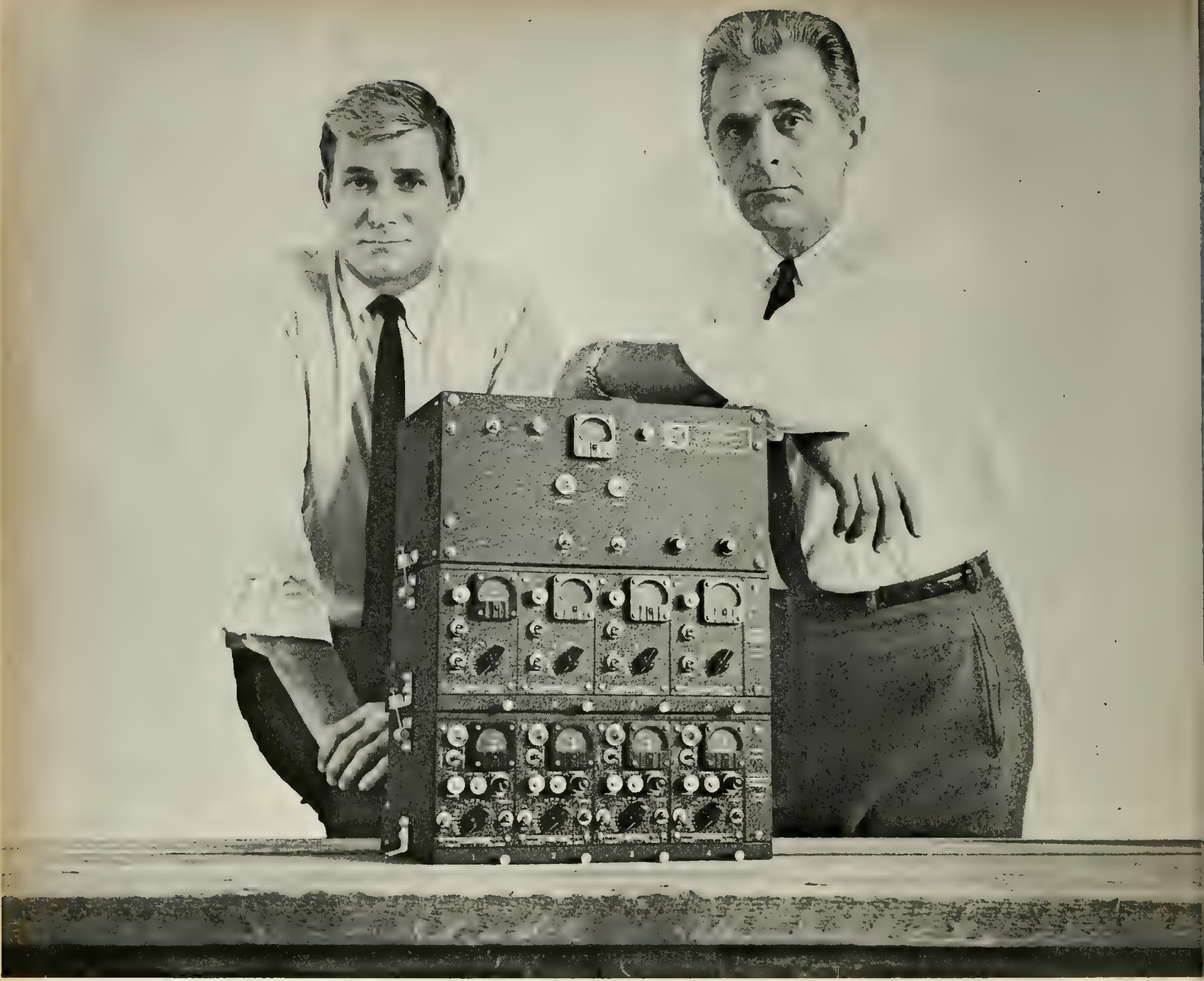
Going into the matter further, Saenger explained he was working closely with Eurospace, a European organization of about 200 companies with the common goal of bringing missile/space business to the continent. "I am assisting a German group within Eurospace in looking into the economics of space transportation. We are considering reusable vehicles. *Dyna-Soar* is assumed to be the necessary first step."

- **Prophesied Dyna-Soar revival**—Saenger said that if *Dyna-Soar* were cancelled (which it was late in 1963), someone would have to re-institute it. "We consider it essential to develop an aerospace plane able to lift off from Earth, go up to orbit in the form of an airplane with wings, return like the *Dyna-Soar* along a glide path to Earth and land like an airplane so it can be re-used," he said.

For the aerospace plane itself, "my personal opinion favors a one-stage vehicle," he said, "if we can get a high-energy motor with a specific impulse of about 450 seconds, such as with hydrogen/oxygen propellants. We are trying to see if we can get a motor from the U.S. or must develop one ourselves. The question is completely open now."

The chemical rocket-sled idea for launching an aerospace plane into space was modified by Saenger into a steam-rocket sled. "We are looking into the structural framework and hardware for such a catapult," he said. "It could be cheap to develop and use."

He said he had developed such a steam rocket, which was on a test bench at the Stuttgart Institute of Jet Propulsion Physics, where he had taught. "It develops 30 tons of thrust. We ran hundreds of tests on it. We would use it to accelerate a stage to subsonic or perhaps supersonic velocity." He said in this way a two-stage aerospace vehicle could be developed, with one stage never leaving the ground.



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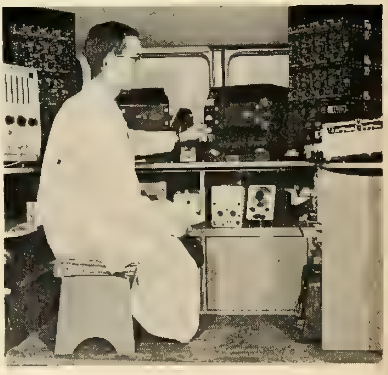

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- **Steam concept not new**—Saenger admitted that the idea of a steam rocket is not new; in fact, "it's about 250 years old." In Stuttgart, "the first experiments began in 1956 and continued until 1961," he said. "At the beginning, we had small thrusts—several hundred kilograms. At the last installation, we reached the 30-ton figure for about 10 seconds." For a flight launch, "we need a short-time thrust of about 6 to 10 seconds in order to give a 2- to 3-*g* acceleration."

Looking ahead at the propulsion picture, Saenger said "the next full step will be taken with the application of nuclear energy to rocket motors—of the kind of the Rover system in which hydrogen is heated up by a fission reactor." He said there is "a lot of interest in Europe in this system, that is, research interest. Eurospace would like to use such a motor for European space vehicles."

Hypersonic ramjets for space vehicles "will be difficult to develop and will take time, perhaps beyond the 1970's and 80's," said Saenger. "I feel that until we have solved the technical questions for such an engine, we perhaps should go along with Rover."

- **Saenger in Egypt**—"I was asked in the spring of 1960 by the Egyptian government to give lectures at Cairo University and help the country by doing consulting work on meteorological sounding rockets," the scientist said. "I was told: 'The Israelis now have sound-

Background on Egyptian Rocketry

EGYPTIAN PRESIDENT Nasser decided to build an Arab rocket in the spring of 1960 when Israel shot up its own meteorological rocket. Today there is little question that Egypt's *Al Zafer* and *Al Kaher* missiles, now being produced in volume at the Heliopolis 333 plant near Cairo, have any but military purposes.

By making its own missiles, Egypt insured itself against getting obsolete armaments from the Soviet Union. Egypt has already received from Russia the *SA-2* ground-to-air antiaircraft missile, the same that was in Cuba and probably the same that shot down Powers' U-2; the air-to-air *ATOL* normally supplied in the fuselage of the MIG-21, an IR heat-seeker of the *Sidewinder* type, which Cuba did not have; and the *Komar,* a ship-to-ship missile carried by torpedo boats.

But Egypt was subject to the slightest pressure from Russia as long as Egypt could not turn out, at least in part, some of its own armaments. This situation led to Egypt's contacting airplane designer Willie Messerschmitt for the development in Egypt of the supersonic HA-300, a plane designed to be the equal or superior to the French-built Mirage IV, Israel's hottest plane.

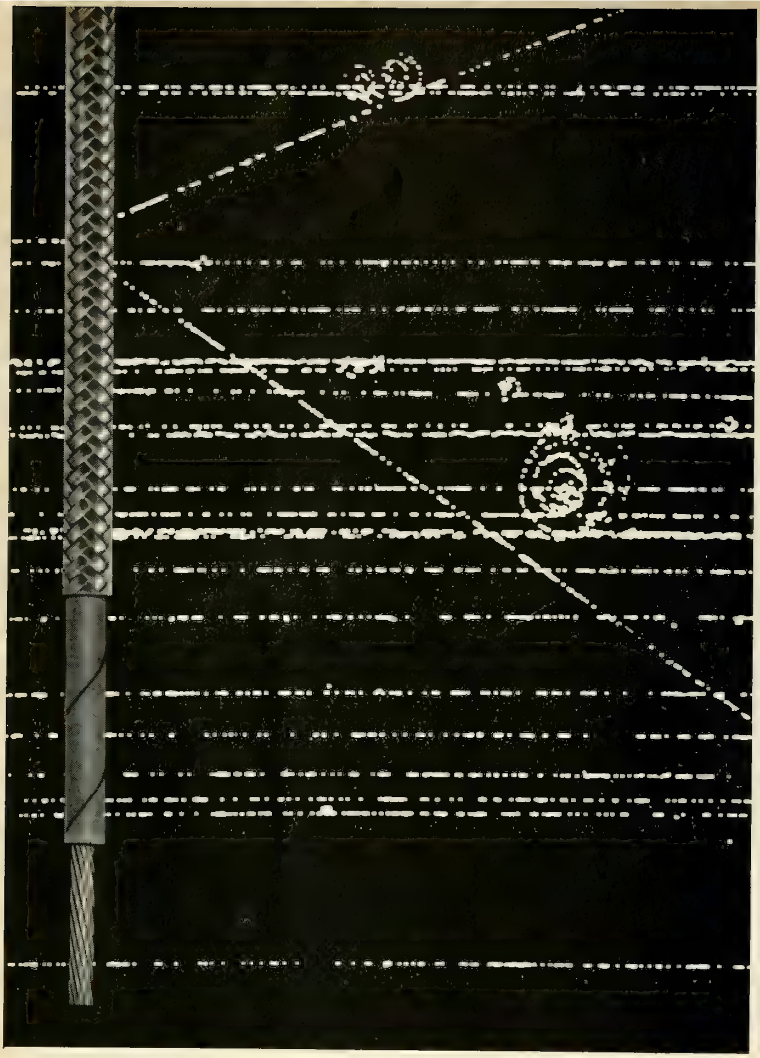
According to intelligence reports gathered by MISSILES AND ROCKETS, Egyptian army officers early in 1961 made contact with West German rocket experts at Dr. Eugen Saenger's office at the Institute of Jet Propulsion Physics in Stuttgart. Several of these experts had worked at the rocket complex at Peenemünde during World War II, and later, on France's *Veronique* and *Super-Veronique* rockets.

One of these men was Wolfgang Pilz, who in April, 1960, sent a memorandum to the Bonn government and to European industrial organizations proposing construction of a satellite launcher, which, he claimed, would equal the performance of the launcher based on the *Blue Streak* space booster, but cost only one-quarter as much, about 100-million DM ($25 million).

It is said that no answer was ever received to this proposal, and the rocket experts decided Europe was no field for their talents and should look elsewhere. Thus, when the Egyptian query came, Pilz, who is an expert on rocket fuels, and Paul-Jens Georcke, an expert on guidance and controls, were quick to negotiate and leave for Africa. Hans Kleinwachter, who joined the group somewhat later, is also an expert on guidance and electronics.

Today, the three West German scientists are presumably directing operations in Egyptian rocketry, to the embarrasment of the West German government. These men, threatened with loss of their West German citizenship, have declared, according to some witnesses, they would become Egyptian citizens rather than give up their work.

One note, consistently struck by nearly every West German queried about the German rocket experts working for Nasser, was—"their business is rocketry and if Germany couldn't use them they had no choice but to go elsewhere to earn their living."



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ing rockets that can go up 200 kilometers. We, too, would like sounding rockets going up more than 200 kilometers.'

"I saw no difficulty and consulted with the Egyptians by visiting them every two months with two of my colleagues: Wolfgang Pilz and Paul-Jens Goercke. Later, another man, Hans Kleinwaechter, joined the group in Egypt.

"In the fall of 1961, my government asked me to stop this work and I did. My government also asked me to ask my colleagues to stop and I did, but they wouldn't," said Saenger.

In 1962 and 1963, Egypt paraded and demonstrated its "home grown" rockets. Press reports said they were anti-Israeli missiles and Egyptian president Gamal Abdel Nasser boasted they could reach "a little south of Beirut," thus holding all of Israel in their kill radius.

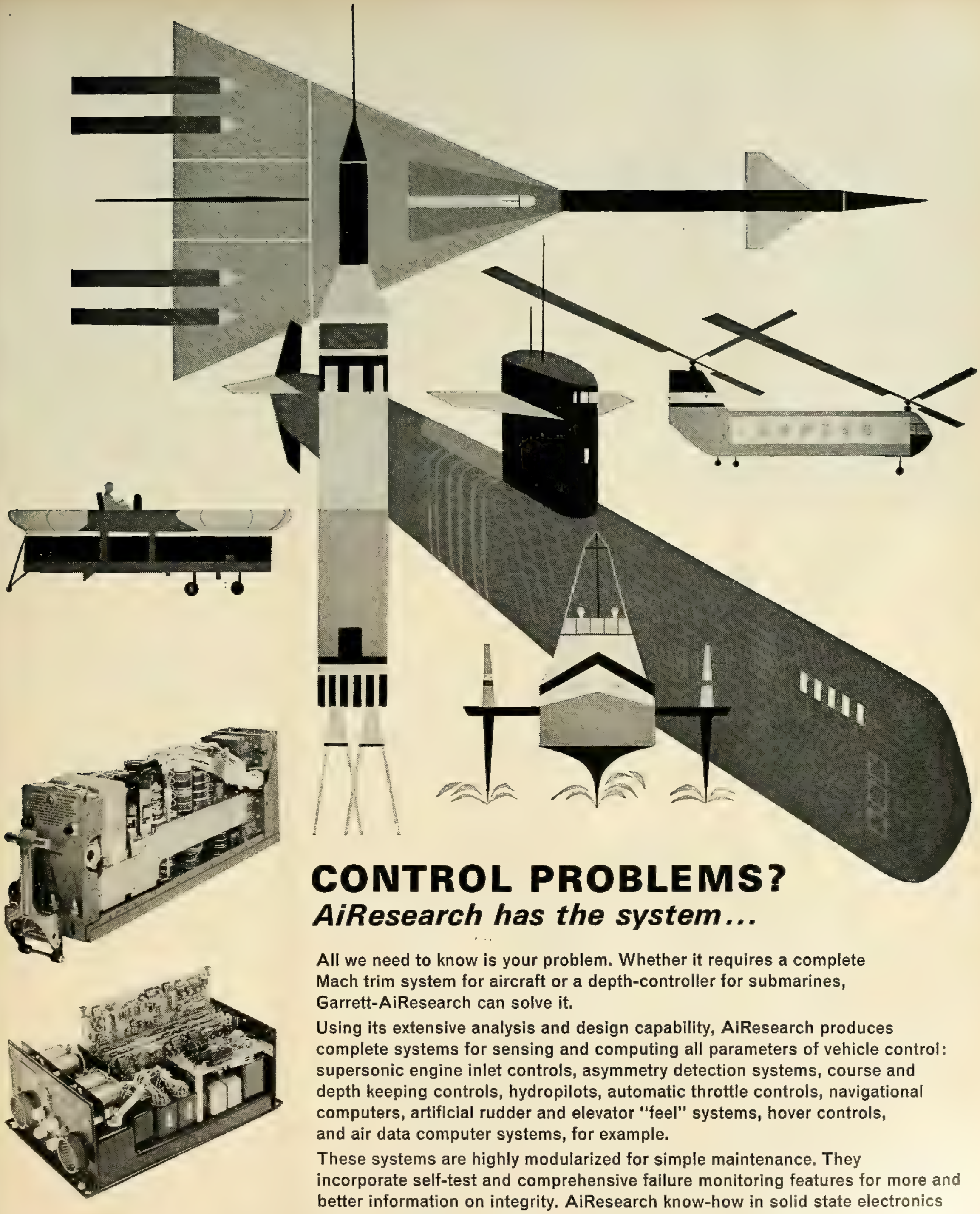
But Saenger affirmed that Pilz and Georcke "are working on nothing else but peaceful rockets." He explained: "It's a rocket only for vertical launching and liquid fuel. There is no guidance. Although in principle the rocket could be launched into an inclined flight, there is no way of knowing with accuracy where it will impact." The scientist paused, then added, "So I can't imagine how it would be used for military purposes."

• **Engines, planes in Egypt**—Saenger confirmed other reports that only a few Germans are working on rockets whereas 300 to 400 foreign technicians—some Austrians, but mostly West Germans—"are developing turbojets and airplanes." Located in a plant at Heliopolis, a town near Cairo, "the engine work is under the direction of Ferdinand Brandner, an Austrian-born engineer." Saenger said he had no details about the airplane development.

He maintained, "The Egyptians are eager to develop the industry of their country so that they can be one of the leading industrial nations in Africa." He said, "They have an extremely crowded population. They have the problem of maintaining life and they see possibility (for growth) only in heavy industry. They intend to sell the turbojets to other countries."

Saenger would not discuss his dismissal from the Stuttgart Institute of Jet Propulsion Physics, indicating it was an experience too filled with remembrances and emotions.

His last words to MISSILES AND ROCKETS were a hope and a caution: "There is a brilliant future for the world as it goes into space. Yet the young people do not know the difficulties of the work. We should not promise them too much." ■



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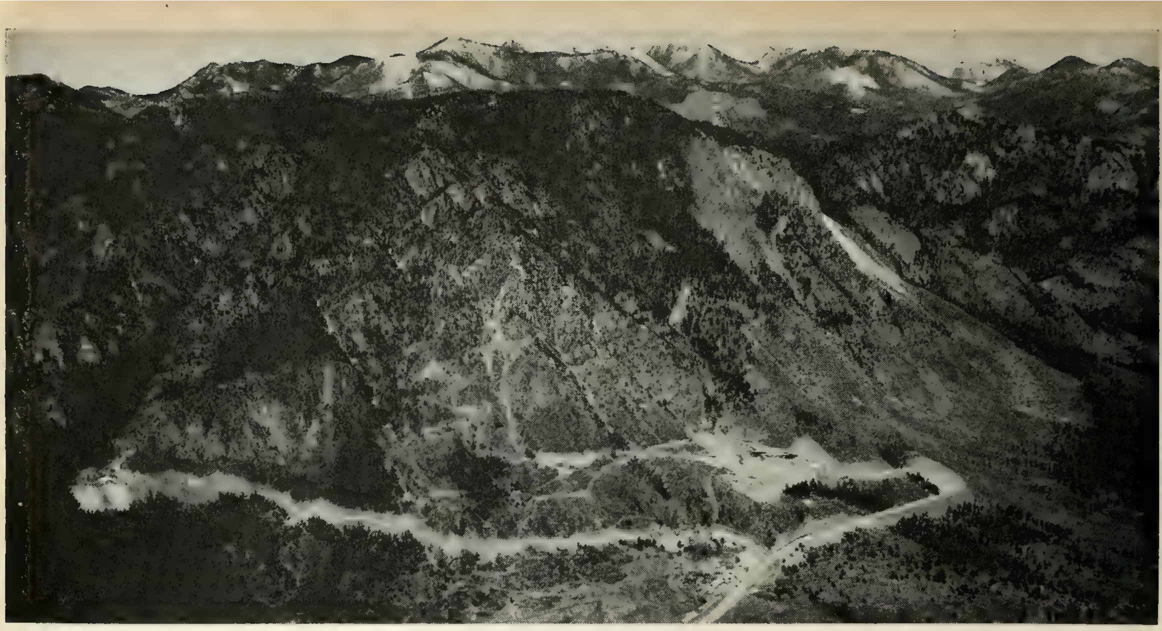


CHEYENNE MTN. area of NORAD's COC. Pike's Peak in background.

Agencies scramble for space . . .

Air Force Presses to Meet 1965 Date For Operation at NORAD Hard Site

by Michael Getler

COLORADO SPRINGS, COLO.—Construction of the North American Air Defense Command's nuclear-hardened Combat Operations Center (COC) deep inside Cheyenne Mountain, near Pike's Peak about seven miles southwest of the present NORAD command post here, has passed the halfway mark. The Air Force now estimates that the huge complex will become operational late next year.

The program to ready the site, a truly enormous undertaking during which more than a million tons of earth and granite were blasted and removed, has slipped about six months thus far. Total cost of the project is estimated at $88.7 million.

Steelwork is either completed or in progress on more than half of the 11-spring-mounted steel buildings which will provide some 170,000 sq. ft. of floor space for the center's operations. The NORAD COC is located roughly at the 7,000-ft. level of the 9,440-ft. Cheyenne Mountain. The heart of the operating areas is burrowed about ¾ mile inside the mountain, with some 1,200-1,400 ft. of virtually solid granite providing the natural roof above the buildings.

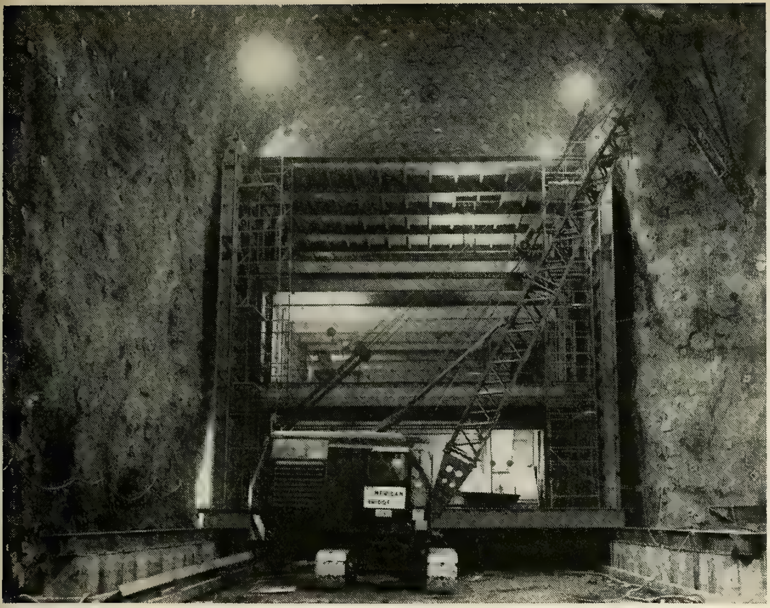
- **Elbowing begins**—Despite the huge dent made in the mountain's innards, a scramble for floor space has already developed among various government agencies and commands that will have facilities in what NORAD officers call "The Hole."

The Cheyenne Mountain site will hold all that the current Colorado Springs buildings contain and quite a bit more. For example, in addition to the new NORAD 425L command and control system, the 496L Space Detection and Tracking System (SPADATS) control center, Ballistic Missile Early Warning System (BMEWS) inputs, joint U.S.-Canadian aircraft and missile air defense force status, SAC liaison, Nuclear Detection System (NUDETS) and National Warning System operations, it is currently planned to put a major new 16,000-sq.-ft. Defense Communications Agency facility into the mountain, an Intelligence Data Handling System, (reportedly a suborganization of the Defense Intelligence Agency), a weather unit larger than the current one at NORAD, and spaces for the Federal Aviation Agency (FAA) and DOT (Dept. of Transportation, the Canadian equivalent of FAA).

To prevent having each of these agencies work independently on space plans, a study group set up at the direction of the Dept. of Defense is now meeting here to cut everybody down to size. The study is expected to be completed in about three months.

Eight of the COC buildings will be three-storied structures and three will be one and one-half stories. The spring shock-mounts, 937 of which are used, each weighs 1,500 lbs., is 4 ft. high and 2 ft. wide, and is made of 3-in.-dia. steel. The entrances to the two-lane access tunnels (the site contains some 3 miles of major tunnels) will be sealed off by two 30,000-lb. steel blast doors which form an airlock. Communications antennas serving the complex and redundant multiple-path cabling also are being hardened out to distances believed to be on the order of 30 miles for the cabling.

While the job of opening up tun-



STEEL construction work proceeds on COC buildings beneath 1,400 ft. of granite.

nels as much as 45 ft. wide and 25 ft. high for distances of hundreds of yards is not considered to be pressing current construction methods, workers at the site believe that the excavation of the 45 x 60-ft.-high chambers and 60 x 60-ft. tunnel intersections may represent some of the largest of their kind ever constructed.

- **Hardest yet**—The complex, which will house 250 men per 8-hr. shift during normal operating conditions and up to 750 persons in emergency situations, is designed to withstand anything but a direct hit with a thermonuclear weapon, the Air Force says, and to provide survival capability of up to a month for the staff.

Actual overpressures which the site could survive are classified; however, as one officer points out, it is in fact extremely difficult to assess the real hardness of a site of this type. Whatever the actual figures, the NORAD COC is expected to represent a higher degree of protection from nuclear attack than has ever before been achieved—providing a sharp contrast to the existing above-ground headquarters here which NORAD's former chief, USAF Gen. Earl E. Partridge, said "one man with a well-aimed bazooka shot could immobilize."

Though the NORAD COC will be the biggest and hardest site of its kind in North America, it will not be the first such complex. A much smaller version of this type of facility has just been placed into operation at NORAD's SAGE (Semi-Automatic Ground Environment) complex in North Bay, Ontario. The Canadian facility has been mentioned as a possible alternate command post should the Cheyenne Mountain unit be disabled.

There are currently alternate command posts for the existing NORAD headquarters, though the locations are classified. The Air Force has reported that the SAGE computers at these other locations could handle the headquarters function.

Construction of the new COC is supervised by the U.S. Army's Corps of Engineers. When completed, it will be turned over to the Air Force's Air Defense Command, largest component of the jointly run U.S.-Canadian NORAD, which, in turn, will place it under the control of Commander in Chief-NORAD, currently USAF Gen. John K. Gerhart. Deputy commander is Air Marshall C. Roy Slemon, Royal Canadian Air Force.

Above-ground testing of portions of the 425L system also is now going on here. This phase of the program is aimed at enabling the equipment to be checked out and moved into the site very soon after construction is completed.

Burroughs Corp. is the systems hardware contractor for 425L, which is designed to provide a highly automated high-speed computer and display complex for CinC NORAD, allowing analysis of sensor inputs and command status. The system will use a Philco 2000 computer. Value of the Burroughs award has been estimated at about $58 million, however total cost of the system is expected to be much higher.

In addition to Burroughs, Mitre Corp. is assisting the AF's Electronic

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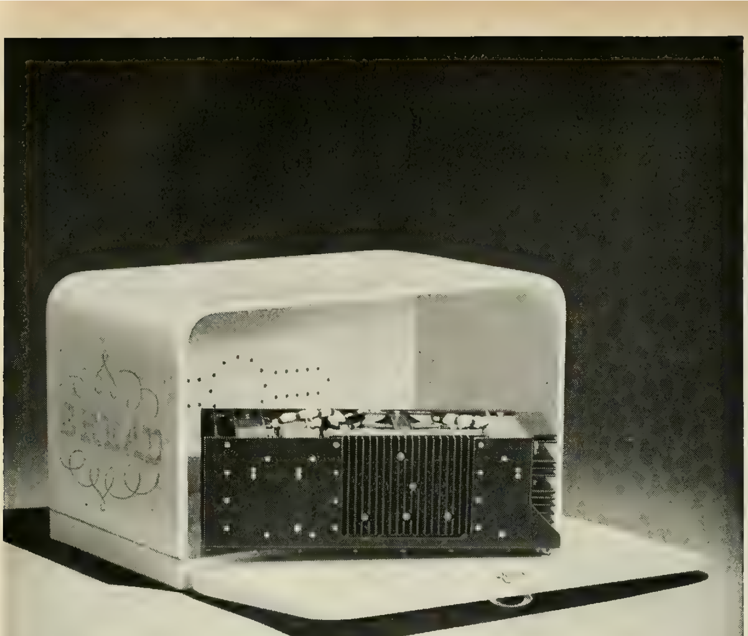

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Systems Div. (ESD) in systems design, and the Systems Development Corp. is handling the computer programming in much the same role it played in development of the SAGE system.

Apart from work on the new COC and 425L development, several other projects now moving into test stages around the country may well affect NORAD's future aerospace detection capabilities.

- **Phased array**—At Eglin AFB, Fla., MISSILES AND ROCKETS has learned, the 13-story building which will house the high-power phased-array satellite tracking radar there has been completed, and testing of installed radar subsystems and components will get under way in July. First full test of the $30-million Bendix-built FPS-85 radar (M/R, Oct. 15, 1962, p. 15) is expected this fall. The radar will be performance-tested and evaluated during a subsequent nine-month period which could lead to its operational use in the SPADATS net.

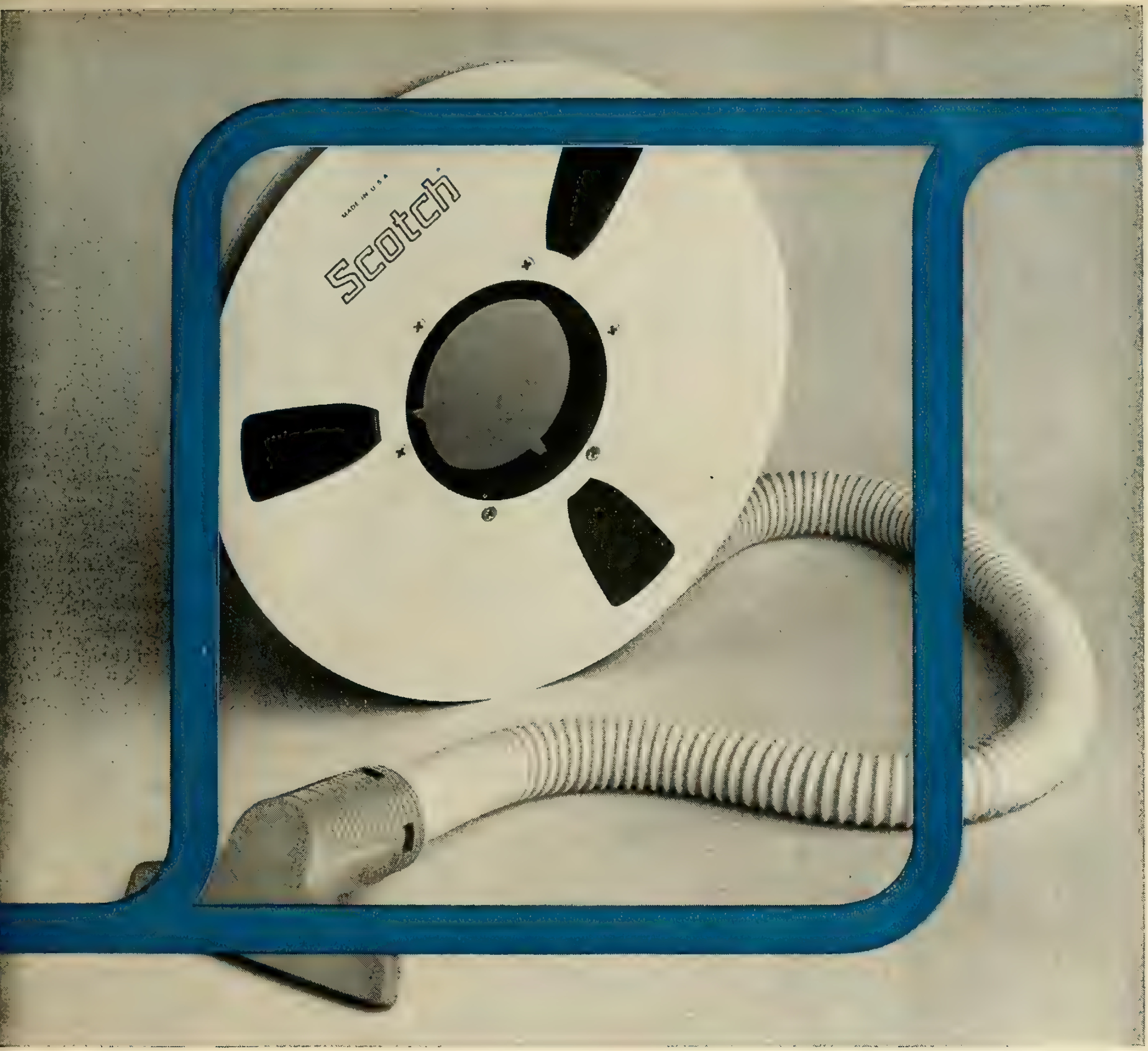
No current follow-on has been disclosed in this program, but Air Force scientists at ESD point out that the test-period results will have an important bearing on addition of improved radars of this type. The 320-ft.-long, 150-ft.-high, 130-ft.-deep, southward-facing electronically scanned array, will, it is hoped, significantly extend both the range, the ability to simultaneously track multiple satellite targets, and the ability to gather satellite configuration data via radar.

- **Optical system**—At Cloudcroft, N.M., the Air Force also expects to put its Prototype Optical Surveillance System into operation in June. This system, which will be housed on a 9,000-ft. mountain location, is expected to push the satellite tracking state of the art even further than the Eglin radar, according to project sources, though the two are obviously intended for different regimes.

The optical system, being built by RCA's Burlington, Mass. Div., is aimed at detecting and tracking satellites from the outer range limits of available radar skin tracking (generally about 2,000 miles, according to Air Force estimates, for a 1-sq.-meter target) to lunar distances. RCA hopes to accomplish this using image orthocon amplification techniques to measure reflected solar energy and a pre-determined scanning method to cancel star and planetary backgrounds.

The system, with respect to operational introduction into SPADATS, occupies about the same position as the Eglin radar; the decision on its inclusion will rest heavily upon subsequent tests.

- **Over-the-horizon**—Planners are also known to be taking a hard look at



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introduction of over-the-horizon radar into the missile/space surveillance inventory. Operation of a prototype system was mentioned by Defense Secretary McNamara in his recent budget testimony (M/R, Feb. 3, p. 9) and was also described as "highly promising" by NORAD briefers here this week.

Basically, two types of over-the-horizon techniques are being pursued—forward-scatter and back-scatter, with the latter having been under development for a longer period. Despite the longer development attention paid to back-scatter, informed Air Force officers feel that the choice between the two is not yet clear-cut and that many competent scientists would defend either approach.

It is known that both types of systems have been built and are now operating. However, according to ESD sources, the tests in the field with the forward-scatter method are being run with basically laboratory equipment not yet in the prototype stage. Observers estimate that operational use of these techniques in systems such as SPADATS is still some 3-5 years off.

SPADATS planners, while concerned with sensor developments, are also becoming increasingly concerned about getting information from global satellite sensors back into U.S. command and control nets quickly, and handling the enormous amounts of data that will build up as the amount of space traffic increases and the art of detection improves. An inexpensive and reliable communications systems is needed, they report—quite possibly a satellite system.

- **Current SPADATS**—The current operational SPADATS net is widespread and provides an extensive detection capability which NORAD can be expected to press on with in addition to its effort to bring into being forces capable of identifying and intercepting, if necessary, hostile vehicles.

Major military inputs to SPADATS come from the USAF Spacetrack System, including BMEWS, and the Navy's Space Surveillance System which stretches across the southern United States from California to Georgia. Other Air Force ADC-operated radars feeding the Spacetrack net are at Shemya, Alaska, Laredo, Tex., and Moorestown, N.J. The Navy net includes three powerful transmitter stations in Arizona, Texas, and Alabama, and four receiver stations in California, New Mexico, Mississippi, and Georgia.

Baker-Nunn cameras used by the Air Force, RCAF, and Smithsonian Astrophysical Observatory provide optical observation and photography to altitudes of 100,000 mi. RCAF also has a tracking radar at Prince Albert, Saskatchewan.

In addition, NASA's Minitrack network provides inputs, as does the AF's *Discoverer* Satellite Network at Sunnyvale, Calif., all three national missile test ranges, and NASA's Goddard Space Flight Center.

As an example of the growing job of space detection and identification, a box score of space activity at NORAD as of Feb. 12 shows the following:

	US	UK	CAN	USSR
Payloads in Orbit	84	1	1	7
Space Probes....	5			4
Earth Orbit Debris..........	304		2	9
Space Probe Debris..........	4			
Total Objects in Space........	397	1	3	20
Objects Decayed..	175			155

A total of 751 space objects had been catalogued at that date at the SPADATS control center. ∎

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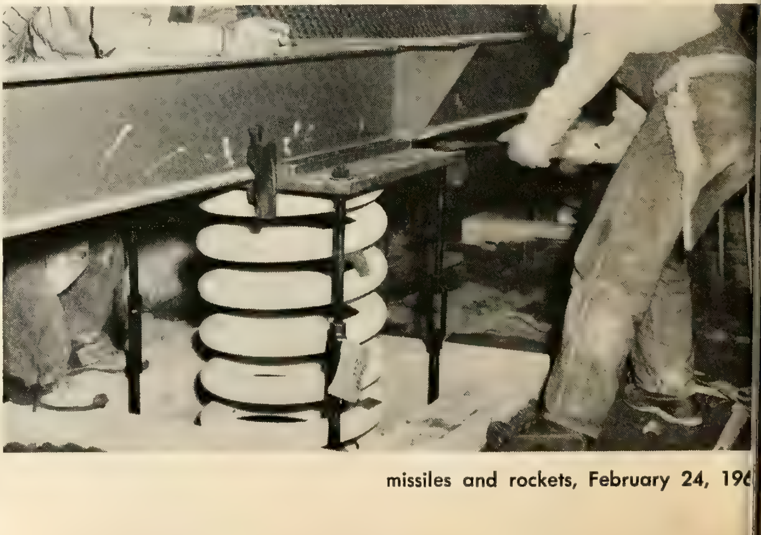

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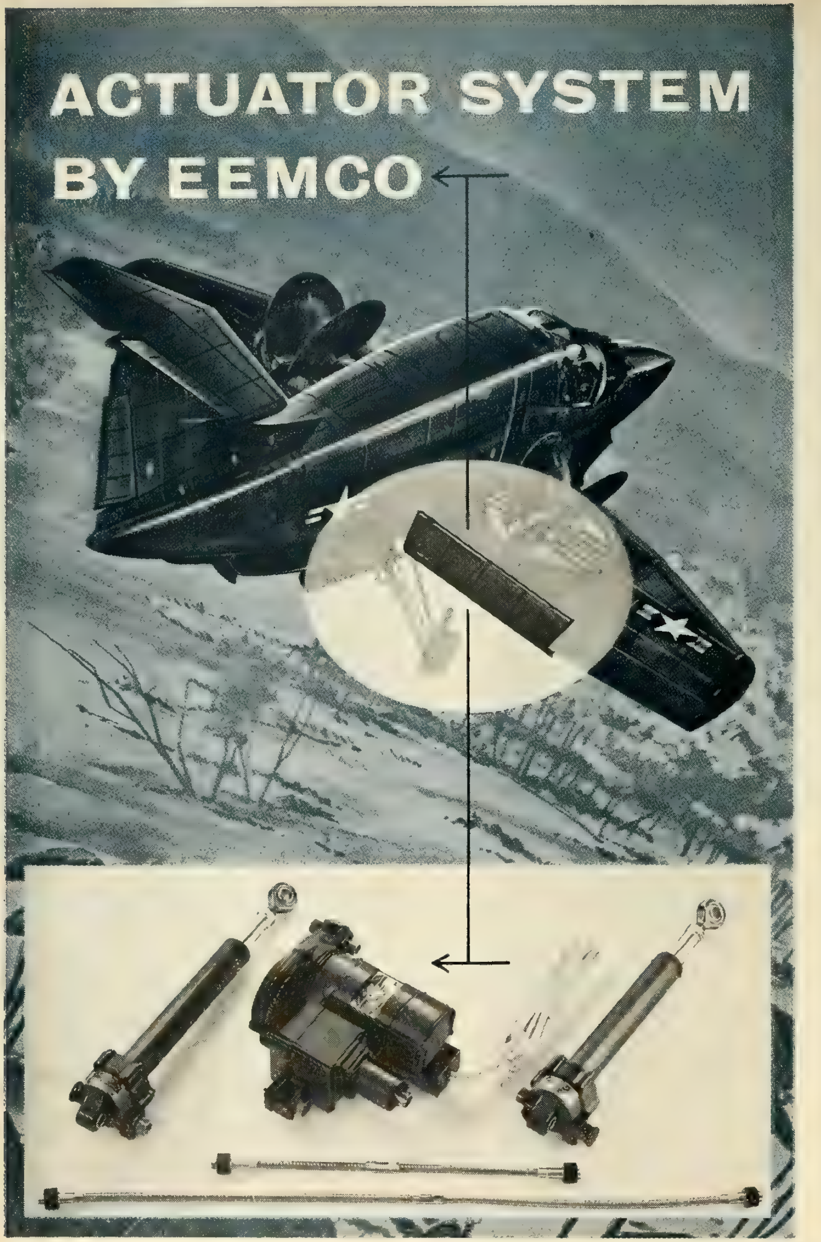

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For information concerning the corporate systems capability, product line, or research and development programs, write to the Director of Marketing, Electronic Specialty Co., 5121 San Fernando Rd., Los Angeles, Calif. 90039.

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Mergers and Acquisitions

Stellarmetrics, Inc., Santa Barbara, Calif., has acquired the entire telemetry equipment line of SKG, Inc., Anaheim, Calif., in a cash transaction. The move gives Stellarmetrics complete capability in the development and manufacture of telemetry communications systems for airborne and ground-based tracking networks. . . . *United Aircraft Corp., East Hartford, Conn., has acquired Vector Manufacturing Co., Trevose, Pa., designers and makers of telemetry equipment and other electronic systems. Vector will become the Vector Dept. of Norden Div. of United Aircraft.* . . . Consolidated Vacuum Corp., Rochester, N.Y., has purchased Ion Engineering, Inc., Minneapolis, Minn. Ion Engineering works in the field of vacuum thin-film, low energy sputtering of metals and alloys and has developed equipment and processes for adapting the sputtering principle to microelectronics. The purchase involved total assets, including all manufacturing equipment. . . . *Fairchild Camera and Instrument Corp., Syosset, N.Y., has acquired Electro-Sensitive Products, Inc., Amsterdam, N.Y., and has changed the name of that organization to Electro-Metrics Corp. Products will include electro-magnetic interference measuring equipment and related components.*

New Activities

Aerospace Industries Assoc. of America, Washington, D.C., has created an Aerospace Technical Council (ATC), composed of ranking research and engineering officials of some 50 major aerospace companies. The new group was created with three major objectives in mind: (1) to act as the industry's top-level advisory board on technical matters; (2) to concern itself with forward thinking and policy planning in technical areas; (3) to provide overall supervision and policy guidance for AIA's Technical Service and the various AIA technical committees. . . . *Solar, a San Diego, Calif., division of International Harvester Co., has established a new Advanced Development department. Organized to increase Solar's capabilities in the field of advanced missile/space manufacturing, the department will work with structures and processes that represent the most advanced technology in the field. It will concentrate on processing exotic materials for aircraft and missile applications, such as the Apollo and supersonic transport projects.*

Industry Facilities

York Research Corp., Stamford, Conn., is beginning a $300,000 expansion in its environmental test facilities, which will offer the missile/space industry advanced environmental qualification services in New England. Heart of the new facilities will be a $116,000 vibration system, ordered from MB Electronics, a division of Textron Electronics, Inc. The system will consist of an MB Model C126 exciter capable of exerting 10,000 lbs. of force at frequencies up to 3,000 cps, a powerful amplifier to drive the exciter and a random-noise source equipped with an 80-channel automatic equalization system capable of "equalizing" the test load to the desired spectrum shape in only 1 sec. . . . *Beckman Instruments, Inc.'s Systems Div. has delivered a high-speed Model 210 data acquisition and processing system to the Rocketdyne Div., North American Aviation, Inc., Santa Susana, Calif. The system was designed to process data gathered during static test firings of the Saturn J-2 rocket engines. It receives data from sensors attached to the rocket engine, converts the data to a binary coded decimal format and transmits it to a central recording unit for future processing.* . . . Hills-McCanna Co., Chicago, is building a new foundry at Creston, Ia., designed to produce sophisticated magnesium and aluminum alloy castings with physical and metallurgical properties closely approximating those of the alloys from which they are made. The 93,000-sq.-ft. facility, being built on a 27-acre plot, will be known as McCannalloy Div. Capital investment will be close to $2 million. Completion is scheduled for next October. . . . *Microdot, Inc., South Pasadena, Calif., has announced the opening of an eastern area sales office in Bayside, N.Y. The office will supplement the regional sales office in Bedford, Mass. The Bayside office will handle sales of Microdot connector products, coaxial cable and electronic hardware in Long Island, metropolitan New York and New Jersey.* . . . United Technology Center, Sunnyvale, Calif., a division of United Aircraft Corp., has activated a new 350-acre Research and Advanced Technology Complex, valued at nearly $1 million. The Coyote, Calif., complex provides facilities for processing a wide variety of solid propellants of less than 1 gram to 100 lbs. in weight. It contains an office and laboratory building, a ballistics and physical test building, four process pads and a control environmental station for humidity and atmosphere control. . . . *Communication Electronics, Inc., now located in Bethesda, Md., is moving to a new building in the Washington Science Center in Rockville, Md. With 50,000 sq. ft. of laboratory and assembly space, the building more than doubles the space now occupied by CEI in three locations. CEI specializes in radio receiving equipment for surveillance, reconnaissance and telemetry applications.*

Company Representatives

Leslie Co., Lyndhurst, N.J., manufacturer of pressure, temperature and liquid level controls, has appointed Control Center, Inc., Orlando, Fla., sales representative for industrial control equipment in the missile/space, chemical and related industries. . . . *Avco Corp.'s Industrial Products Subdivision has named Richard E. King as district representative in New York, New Hampshire, Vermont, western Massachusetts and northern Connecticut. He will handle wire flame spray metallizing and plasma coating equipment and materials for Avco.*

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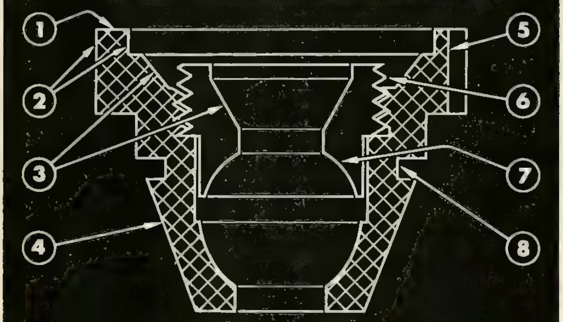

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—contracts and procurements—

AWARDS

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$9,000,000—**Sylvania Electric Products, Inc.**, Mountain View, Calif., for production of electronic security systems for use at *Minuteman* missile sites.

$7,200,000—**Aerojet-General Corp.**, Sacramento, Calif., for continued research and development on *Minuteman* missile stage two engines.

$2,500,000—**Boeing Co.**, Seattle, for continued work on the Minuteman missile.

$2,500,000—**General Electric Co.**, Schenectady, N.Y., for production and overhaul of klystrons.

$1,400,000—**Boeing Co.**, Seattle, for continued work on the *Minuteman* missile.

$1,200,000—**Cornell Aeronautical Laboratory, Inc.**, Buffalo, N.Y., for satellite work on an experimental basis.

$1,000,000—**Space General Corp.**, El Monte, Calif., for further production of *Able-Star* vehicles.

$1,000,000—**Sperry Rand Corp.**, St. Paul, Minn., for aerial computers for a study of maneuvering space vehicles.

$1,000,000—**Aero-General Corp.**, Sacramento, Calif., for further work on a micro-wave system for use at Vandenberg AFB, Calif.

$500,000—**American Optical Co., J. W. Fecker Div.**, Newark, Ohio, for design and production of three multi-purpose equatorial test turntable systems for use at the 2802 D inertial guidance calibration laboratory.

$324,000—**Packard Bell Computer**, Los Angeles, for a telemetry data conversion system to be installed at the Air Proving Ground Center, Eglin AFB, Fla.

$200,000—**California Institute of Technology**, Pasadena, Calif, for a research program on solid propellants and their physical behavior.

$174,992—**Aerojet-General Corp.**, Azusa, Calif., for a study of an optical periscope for use on liquid rocket thrust chambers.

$74,447—**General Applied Science Laboratories, Inc.**, Westbury, N.Y., for study of hypersonic combustion.

$52,203—**Cornell Aeronautical Laboratory, Inc.**, Buffalo, N.Y., for research on nonequilibrium effects in supersonic flows.

$41,379—**Brown University**, Providence, R.I., for research on electrical conductivities and energy transformation in a plasma.

Lockheed Propulsion Co., Redlands, Calif., for a demonstration of feasibility of pulsed operation of solid propellant rocket motors (undisclosed amounts).

ARMY

$15,900,000—**International Business Machines Corp.**, New York City, for automatic data processing equipment formerly held by the Army under lease arrangement.

$12,900,000—**Day & Zimmerman, Inc.**, Philadelphia, for assembly of boosters, rockets, etc.

$4,100,000—**Thiokol Chemical Corp.**, Bristol, Pa., for loading and assembly of *Sergeant* missiles.

$2,000,000—**General Telephone and Electronics Corp., Sylvania Electric Products Div.**, Fort Huachuca, Ariz., for modifications to a mobile digital computer.

$1,700,000—**IT&T Corp., ITT Kellogg Communications Systems Div.**, Chicago, for development and production of related parts for communications systems.

$1,300,000—**Ralph M. Parsons Co.**, Los Angeles, for engineering services related to the *Nike-X* missile system.

$200,000—**Hughes Aircraft Co.**, Fullerton, Calif., for an array antenna component development program radial feed.

$137,000—**Sperry Rand Corp., Sperry Utah Co.**, Salt Lake City, for work on the *Sergeant* missile system (two contracts).

$86,736—**Northrop Corp., Nortronics Div.**, Anaheim, Calif., for *Hawk* wing assemblies.

$70,802—**Northeastern University**, Boston, for contribution of studies on the biological effects of laser radiation.

Perkin-Elmer Corp., Norwalk, Conn., for an optical re-entry instrumentation system designated Project GLOW (undisclosed amount).

NAVY

$5,282,280—**General Instrument Corp.**, Hicksville, N.Y., for electronic counter-measures equipment.

$2,800,000—**Control Data Corp.**, Minneapolis, Minn., for production of target card computers for *Polaris*.

United Technology Center, Sunnyvale, Calif., for investigation of hypergolic ignition of solid propellants (undisclosed amount).

NASA

$6,000,000—**Genisco, Inc.**, Los Angeles, for development, fabrication and assembly of a weightless motion generator for spaceflight application.

$1,800,000—**General Dynamics/Astronautics**, San Diego, Calif., for *Orbiting Astronomical Observatory* shroud system and Point Loma test program.

$700,300—**Space General Corp.**, El Monte, Calif., for an improved version of the *Astrobee* rocket #1500.

$96,740—**Radio Corp. of America**, New York City, for development and testing in connection with Lewis Research Center to determine high-magnetic-field superconduction properties of Nb35n films on insulator and magnetic substrates.

$94,000—**Standard Pressed Steel Co.**, Jenkintown, Pa., for research work on cryogenic fasteners.

$73,021—**Teletype Systems Corp.**, Hawthorne, Calif., for a toxic vapor detection system.

United Technology Center, Sunnyvale, Calif., for investigation of hypergolic ignition of solid propellants (undisclosed amount).

MARINE CORPS

$4,000,000—**Electronic Communications, Inc.**, St. Petersburg, Fla., for tactical communications systems including components for the Marine Corps Tactical Data System.

AEC

Dynatech Crop., Cambridge, Mass., for a long-range experimental study of forced convection burnout in liquid-cooled nuclear reactors (undisclosed amount).

INDUSTRY

$12,400,000—**Sylvania Electric Products, Inc.**, Waltham, Mass., from **Bell Telephone Laboratories**, for radar work related to the *Nike-X* program.

$362,000—**Precision Instrument Co.**, Palo Alto, Calif., from **Lockheed Missiles & Space Co.**, for provision of additional satellite recorders for the *Agena* space vehicle programs.

$330,000—**Computer Products, Inc.**, Belmar, N.J., from **North American Aviation, Inc.**, for three Mark III general purpose analog computers.

$201,000—**United Aircraft Corp., Norden Div.**, Norwalk, Conn., from **General Dynamics/Fort Worth**, for production of pressure ratio indicator systems for the F-111 (TFX) aircraft.

$140,000—**Interstate Electronics Corp.**, Anaheim, Calif., from **Philco Corp.**, for work on display consoles for the Space Flight Integrated Mission Control Center at Houston.

Hercules Powder Co., Wilmington, Del., from the **Boeing Co.**, for development of a propulsion unit for HIBEX (undisclosed amount).

Ryan Aeronautical Co., San Diego, Calif., from **Space Technology Laboratories**, for fabrication work on the descent rocket engine for NASA's LEM.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Office of Naval Research
Washington, D.C.

The Office of Naval Research has received an unsolicited proposal from Washington Technological Associates, Inc., Rockville, Md., concerning propriatory ideas for research and development, fabrication, test and evaluation of solid-state electrometer amplifiers for rocket and satellite applications and is considering the award of a contract to this firm in accordance with their proposal.

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Va.

Langley Research Center is negotiating a contract with Space Technology Laboratories for modifications to government-owned Space Technology Laboratory's image converter camera system. This notice is for information only. RFP L-4271 not available.

Purchasing Branch
Special Contracts Div.
Procurement and Production
U.S. Army Missile Command
Redstone Arsenal, Ala.

Meter, frequency and power assembly views. Fed. Stock No. 1430-803-4886. Ord. Part No. 8173652. Sixteen each. IFB AMC(Z)01-021-64-1087B. Bid opening 2:30 p.m., March 18. Drawings and bid sets available from nearest procurement district.

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Md.

GSFC will negotiate with the Biochemical Dept. of Hazleton Laboratories for study, development and fabrication of an ATP biological experiment laboratory evaluation instrument. For information only. Proposal packages are not available.

DIRECT DRIVE TORQUE MOTORS
WHAT, WHY AND WHERE

The direct drive torque motor is a servo actuator that can be directly attached to the load it is to drive. It converts electrical signals directly into sufficient torque to maintain zero error in a positioning or speed control system. Most torque motors are frameless and require very little space, offering the greatest flexibility and adaptability in application. They are thin compared to diameter and have relatively large axial holes through the rotor for easy application to shafts, hubs and bosses. In general, torque motors are designed essentially for high torque, "stand still" operation (for positioning systems) and for high torque at low speeds (for speed control systems).

Direct drive torque motors are particularly suited for servo systems where size, weight, power requirements and response times must be minimized and where position and rate accuracies are desirable. Torque motors have these important advantages over other servo system actuators:

high torque-to-inertia ratio: a direct drive motor has the highest practical torque-to-inertia ratio. To respond to an input signal, it must overcome only the inertia of its own, slowly turning rotor and the driven load. Since it is directly coupled to the load, it has no gear train. A gear train increases inertia by a multiple equal to the square of the gear train ratio, resulting in sluggish response.

high coupling stiffness: the direct drive torque motor is attached directly to the load itself — therefore no gears, no backlash errors, no mechanical resonance problems.

fast response: since it produces higher torque for its size than any other electromagnetic device, and since its torque is a direct function of applied current independent of speed (a function of voltage), the torque motor's response is absolute and instantaneous at all operating speeds.

high resolution: the same characteristics that result in fast response from stand still to maximum operating speeds result in "locked-on" resolution. The torque motor is limited only by the sensitivity of the error sensing circuits that command it.

reliability and long life: the basic simplicity and absolute minimum of moving parts makes a torque motor inherently reliable. Extensive design and production experience have put Inland torque motors in most major defense programs of the last decade. These include widely ranging applications under all conditions and environments from thousands of feet underwater to years of unattended operation in outer space.

The variety and number of applications of Inland direct drive torque motors are increasing rapidly in both industry and government. Some typical applications are in:

- stable platforms for inertial guidance
- antenna and telescope drives
- filament winding constant tension drive
- space probe solar cell orientation
- X-Y plotter drives
- precision welding rod drives
- gyro test table rate and tracking
- magnetic tape transport
- submarine periscope power assist
- star tracker optics positioning

Inland Motor Corporation specializes in direct drive torque motors and servo subsystems. Having originated most of the designs available today, Inland makes available a design library of over 600 torque motor models. Catalog items range from a small 0.03 lb-ft unit to those that are capable of 3000 lb-ft of torque. Inland also produces rotary and solid state amplifiers, tachometer generators and other units which give them the unique capability to design and deliver complete direct drive servo subsystems for positioning, rate and tensioning applications. Inland's experience, production capacity and complete prototype facilities are distinct advantages to the customer.

TORQY SAYS:

Inland has piled up more information on how to select and use torque motors than a man would ever need. If you want some, call us or write today! A new condensed motor selection guide is hot off the press.

INLAND MOTOR
CORPORATION
Radford, Virginia
703-NE9-3973

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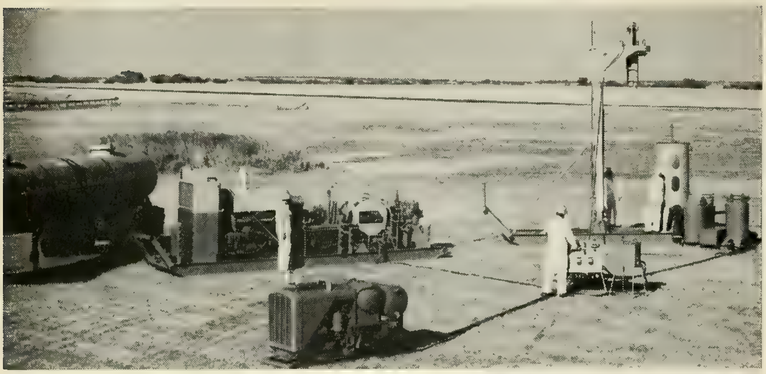


New Product of the Week: Rocket Case Cleaner

Halliburton Co. has developed a new method of removing solid propellants from rocket motors.

The system of reclaiming motor cases is adaptable to a wide range of case diameters and lengths. Solid propellant, rubber liners and fiber glass insulation may be hydraulically sliced, cut and removed from the inside of the motor case. The use of non-abrasive and non-corrosive fluids makes it possible to leave the internal surface of the case smooth, intact and ready for inspection, reprocessing and recharging.

The company has designed several models of rocket and booster motor cleaning fixtures. One is a vertical type capable of removing the solid propellant from rocket motor cases in diameters ranging from 5 to 20 in., having lengths up to 7 ft. The self-contained machine is equipped with remote controls and is hydraulically operated. It is fitted with a fixed lance and all motion is imparted to the motor case.

Another type operates in a horizontal position. It is designed for use with all sizes of rocket motor cases up to 54 in. in diameter and lengths up to 168 in. The fixture holds the rocket motor case in a stationary position and is equipped with a rotating jet lance mounted on a traveling carriage. The machine is hydraulically operated and controlled from remote positions.

All models of cleaning machines are equipped with recirculating fluid systems and include traps, screens and filters to remove the solid particles of material for collection and disposal.

Circle No. 151 on Subscriber Service Card

ANNOUNCING
The Fourth Annual
RELIABILITY INSTITUTE
to be held at
The University of Connecticut
May 31 through June 12, 1964

Staff includes E. F. Dertinger, Romeyn Everdell, Leo Jacobson, David Pertshuk & Dorian Shainin

For brochure or further information, write to:
Prof. Richard Story
Box 41-56
The University of Connecticut
Storrs, Connecticut

Circle No. 26 on Subscriber Service Card

Transducer Test System

Servonic Instruments, Inc., has developed a semi-automatic pressure transducer test system designed for simultaneous testing of four pressure transducers.

The Model E-36A will generate five absolute pressure calibration points over an adjustable range of 0 to 50 psia. Pressure levels are manually selected and accurate to ±0.1% full range. Outputs are individually presented on a digital voltmeter.

The unit can accommodate proof pressures up to 125% of full range with negligible zero shift. Overall system accuracy exceeds ±0.15%.

Circle No. 152 on Subscriber Service Card

Capacitor

Texas Capacitor Co. is marketing an epoxy-encased Mylar and foil capacitor with an operating temperature range of −55° to 85°C.

The unit has voltage ranges of 200, 400 and 600 dc and a standard tolerance of ± 5%. It is also available with ± 10, 3, 2 and 1% tolerance. Insulation resistance exceeds 50,000 megohm-microfarads at 25°C. With 50% voltage derating, the unit will operate to ± 125°C. It can withstand 125% of rated voltage at 85°C for 250 hours. Dissipation factor will not exceed 1.0% at 1,000 ±20 cps at 25°C.

Circle No. 153 on Subscriber Service Card

DC Solenoid

A subminiature dc solenoid with continuous or intermittent duty is available from Tec • Magnetics.

The Model 6-TM-1013 is available in five mounting configurations and operates on 3 to 220v dc. Rated force is 5 oz. with a 0.010 stroke with intermittent duty coil. Operating temperature range is −400° to 500°F. The unit is available with pressurized or non-pressurized plunger cavities.

Circle No. 154 on Subscriber Service Card

Power Dividers

A series of stripline power dividers covering the frequency spectrum from 1 to 12 gc has been developed by Electronics Div. of Electronic Specialty Co.

The four units feature ±3-degree phase tracking between outputs, high isolation, low insertion loss and low VSWR. For example, the X-band unit has a 25-db isolation and a VSWR of 1.5 at mid-band.

Circle No. 155 on Subscriber Service Card

M/R

missiles and rockets

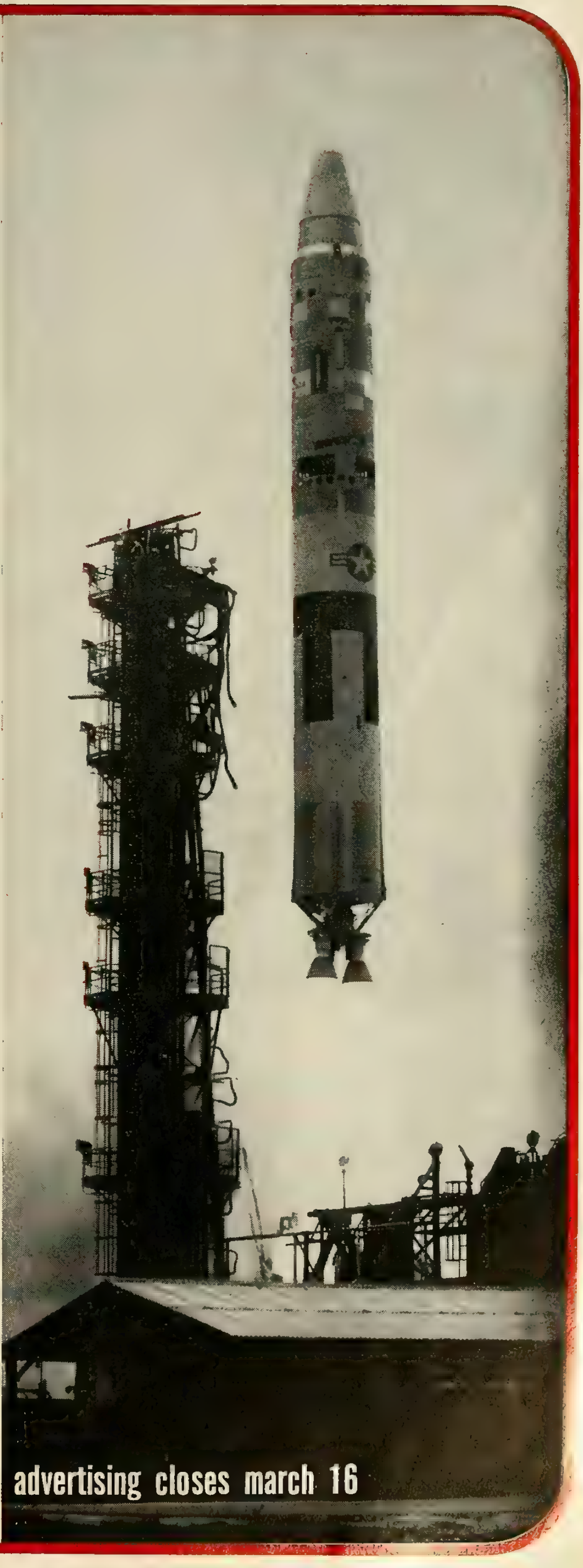
DOD/Military Systems Issue March 30, 1964

One of the most important offices in the Department of Defense is the Directorate of Defense Research and Engineering (DDR&E). It has a complement of 145 men, supervising some 30,000 others and directly affecting over 125,000 industry personnel while annually contracting for $7 billion dollars in space and military systems research, development, test and engineering services from its suppliers.

The March 30 issue of Missiles and Rockets will present an in-depth report covering the DDR&E operation, its relationship with industry and the services, its current and advanced programs, in-house R&D capabilities, future expenditures, and lists of key personnel.

Sell your products, capabilities or services to over 44,000 program and project managers, engineers and scientists by advertising in M/R's DOD/Military Systems Issue.

publication date: march 30, 1964



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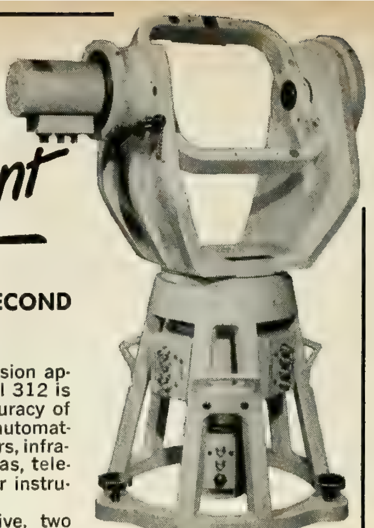

Two Axis Tracking Mount

FEATURES 2 ARC SECOND DIRECT DRIVES

For rigid, lightweight, precision applications, the PTSI Model 312 is now available. With an accuracy of two arc seconds, it can automatically position optical trackers, infrared devices, lasers, cameras, telescopes, antennas and other instruments.

Power-Tronics direct drive, two axis tracking mount has zero backlash and will handle loads of 150 lbs. The entire mount is 32" high and weighs only 100 lbs.

Power-Tronics engineering staff is ready to assist in the application of this or special tracking mounts best suited for your requirements.

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Custom Gimbal Assemblies
Antenna Servo Drives
Electronic & Hydraulic Servo Drives
Navigational Systems
Flight Simulation Tables
Inertial Test Tables

Power-Tronic Systems Inc.
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DC Power Packs

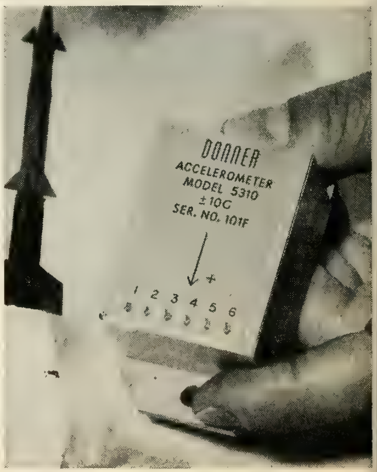
Electronic Research Associates, Inc., has available a line of silicon modular dc power packs.

The units are programmable over a voltage range of 0 to 60v dc and have current ratings from 200 ma to 8 amp. The six models operate with an input of 105 to 125v ac, 50 to 400 cps. Line regulation exceeds ±1.0% for full input; frequency change and load regulation is less than 0.02% for 0 to 100% load change. Ripple is less than 800 µv RMS. Programming constant is 500 ohms per volt. Temperature coefficient is less than 0.01% per degree C.

Circle No. 156 on Subscriber Service Card

Servo Accelerometer

Systron-Donner Corp. is making the Model 5310 flexure accelerometer, able to withstand shock and acceleration of up to 500 g's at 8 millisec.



The device measures acceleration to an accuracy of 0.1% over a range of ±10 g to ±100 g. Ranges may be extended to 500 g and 1.0 g.

Circle No. 157 on Subscriber Service Card

Electromagnet

Magnion, Inc., is marketing the Model CF32-42-23 electromagnet, designed for magnetohydrodynamics studies and large-volume magneto-biology experiments.

The system provides fields in excess of 15,000 gauss over a 432-cu.-in. area with a power input of 15 kw. Power coils permit continuous operation at inputs up to 50 kw.

Back EMF protection is provided; a coolant flow switch and temperature interlock shut off the power supply should the coolant water be interrupted or the energizing coils overheat.

Circle No. 158 on Subscriber Service Card

Sequential Camera

A photographic attachment, designed to take sequential photographs from 17-in. CRT screens, digital voltmeters and similar panel-mounted devices, has been developed by Advanced Technology Laboratories Div., American-Standard.

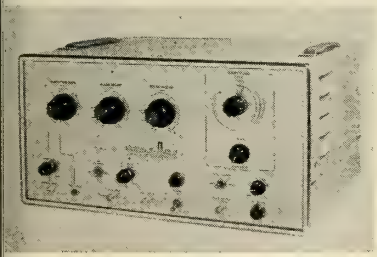
The Model 230 mounts on the front of standard 19-in. equipment racks and allows the operator to view the display while taking pictures. The photographed area measures about 9 x 12 in. and is reproduced on 35 mm. film with a frame size of 0.875 x 1.25 in.

Circle No. 159 on Subscriber Service Card

Pulse Generator

Datapulse, Inc., has available a pulse generator with a pulse output of 50v into 50 ohms at 10 mc and less than 2% overshoot at 7-nsec. rise time.

The Model 108 has a variable rise time from 7 nsec. to 0.05 μsec., pulse widths from 20 nsec. to 5 μsec. at up to 50% duty cycles and up to 5 μsec. variable delay from internal or external triggers. Passive attenuation control provides waveform at any amplitude from 200 mv to 50v.



Circle No. 160 on Subscriber Service Card

Cathode Ray Tube

An electrostatically focused, high-resolution cathode ray tube is being marketed by Electron Tube Div. of Litton Industries.

The model L-4146 has a deflection angle of 40 degrees with a 4¼ in. diameter useful screen area. Spot size is 0.001 in. with a constant resolution from 25 to 15 kv anode voltage. Typical anode voltage is 20 kv.

Circle No. 161 on Subscriber Service Card

Torque Wrench Calibrator

A hydraulically operated torque wrench calibrator with an electronic read-out system from 0 to 2,000 ft.-lbs., is available from Riehle Testing Machines, a division of Ametek, Inc.

The Model TWC-139 has an accuracy of 0.3% of full scale and four different scale ranges: 1,000 in.-lbs.; 5,000 in.-lbs.; 500 ft.-lbs.; and 2,000 ft.-lbs. Operation is either manual or automatic.

Circle No. 162 on Subscriber Service Card

Potentiometer

A hermetically sealed, wire-wound potentiometer designed around a flexible, tubular type metal bellow is available from Ormond, Inc.

The Model APK-6 meets MIL-R-19A specifications and has a life expectancy rated over 10 million cycles. Operating temperature is from —55° to 125°C. All standard resistance values are available in either single or multi-turn construction.

Circle No. 163 on Subscriber Service Card

Solid-State Generator

Rutherford Electronics Co. is marketing the Model B-15 pulse generator, featuring a repetition rate of 5 cps to 5 mc.

The solid-state unit has an external trigger and built-in single shot with delay and width to 10,000 μsec. Output is ± 10v into 50 ohms. Rise and fall times are less than 10 nsec; amplitude is 10v into 50 ohms.

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Opportunities In . . .

MELPAR'S EXPANDING AEROSPACE DIVISION

for Supervisory and Technical Personnel

These positions result from the constant growth of our programs and possess excellent potential for personal advancement.

AERONAUTICS

Projects have both atmospheric and space applications and work includes preliminary design for configurations, drag estimation, stability and control parameter estimation, validation and detail of design by wind tunnel testing, and participation in trajectory studies to assure capability for the mission. Capability for structural analysis (vibration and flutter) is also needed. MS Degree level of competence is desired.

GUIDANCE AND CONTROL

Projects have both atmospheric and space applications and include analysis in both linear and non-linear systems. Some knowledge of the mathematics of optimum controls is desirable as is familiarity with the use of analog and digital computers in solving guidance and control problems. MS level of capability is desired.

OPERATIONS ANALYSIS

To perform operations analysis of complex military and space systems including trade-off studies on sub-system requirements and costs, leading to assessment of the technical and cost effectiveness of the total system. Knowledge of probability theory and its uses as well as use of digital and analog computers is required. MS level of competence desired.

SYSTEM TEST & INSTRUMENTATION

To conduct tests (including field tests) with special emphasis on telemetry systems. Familiarity with range of techniques and equipments for sounding rockets and probes in a developmental program is required.

PROPULSION

Assignments will include preliminary design of small, high performance solid propulsion systems. Problems include grain, case and nozzle design, specifications writing, and technical participation in developmental subcontracts. Knowledge of the use of analog and/or digital computers is essential as is knowledge of the present state-of-the-art. MS level preferred.

For details, write in strictest confidence to:

John A. Haverfield, Manager—Professional Placement

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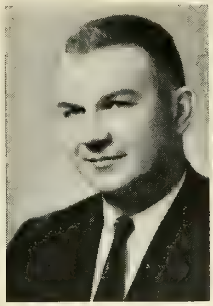
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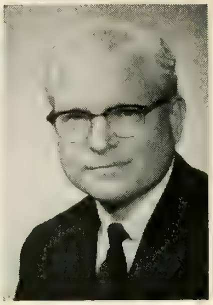
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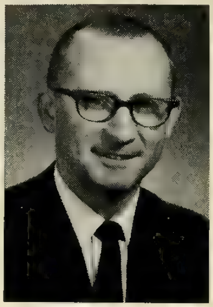
SHANNON

KAHO

Edward A. Anderstrom: Appointed controller for the Metrics Div. of the Singer Co., Bridgeport, Conn.

Dr. Maurice Nelles: Named manager of manufacturing research and development of the Aerospace Div. of the Westinghouse Defense and Space Center, Pittsburgh.

Dennis F. Straiter: Appointed field engineering representative in the northern office of Consolidated Systems Corp., Bethesda, Md.

C. M. Lewis: Appointed manager-operations of the Radio Corp. of America's Washington, D.C. and southern defense marketing region.

Les Daly: Appointed public relations manager in Paris for Northrop International.

Carl V. Shannon: Named program manager for data products at General Dynamics/Electronics, San Diego, Calif.

Kenneth M. Lord: Appointed vice president-commercial for Raytheon Co., Lexington, Mass. **Clyde R. Rockwood** appointed general manager of the Semi-Conductor Div.

Guy K. McCann: Appointed director of advertising and public relations at Vitramon, Inc., Bridgeport, Conn.

Jack R. Kaho: Appointed manager-spares sales for Interstate Electronics Corp., Anaheim, Calif.

G. Edmund Yurowski: Appointed government sales manager of the Bendix Corp.'s Semiconductor Div., Holmdel, N.J.

Earl Goss: Appointed sales manager of the DeMornay-Bonardi Div. of Datapulse, Inc., Pasadena, Calif.

William G. Meschino: Appointed East Coast manager-military products for General Time Corp., New York City.

Wayne E. Phillips: Appointed manager of engineering for the Vacuum Products Div. of Varian Associates, Palo Alto.

Donald J. Jones: Named executive vice president of Centralab, the electronics division of Globe-Union Inc., Milwaukee.

William E. Worley: Appointed director of engineering of the Bendix Mishawaka Div., Ind.

Eugene R. Drossel: Named director of public relations of Kaiser Steel Corp., Oakland, Calif.

Mamerto Benitez, Jr.: Appointed technical director of the Hardman Co.'s newly-created Aerosafety Div., Los Angeles.

Robert D. Wick: Appointed manager of marketing relations for Radio Corp. of America's electronic components and devices organization, Washington, D.C.

James Makris: Joined Page Communications Engineers, Inc., Washington, D.C. as assistant director-range space systems.

Harry S. Burker, Jr.: Named advertising manager of the Clevite Corp., Cleveland.

Howard J. Alsop: Named southeastern regional sales manager for F&M Systems Co., Orlando.

John J. Connolly: Promoted to president of Data Systems Div. of Litton Industries, Beverly Hills.

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—when and where—

MARCH

ASME Gas Turbine Conference and Products Show, Shamrock Hilton Hotel, Houston, Mar. 1-5.

Atmospheric Problems of Aerospace Vehicles, sponsored by FAA and AMS, National Aviation Facilities Experimental, Atlantic City, N.J., Mar. 2-5.

15th Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Penn-Sheraton Hotel, Pittsburgh, Mar. 2-6.

Fifth Symposium on Thermal Radiation of Solids, Sheraton-Palace Hotel, San Francisco, Mar, 4-6.

Southeastern Conference on Theoretical and Applied Mechanics, Georgia Institute of Technology, Atlanta, Mar. 5-6.

AIAA Aerodynamic Testing Conference, Marriott Twin Bridges Motor Hotel, Washington, D.C., Mar. 9-10.

National Association of Corrosion Engineers Annual Conference and Corrosion Show, Sherman Hotel, Chicago, Mar. 9-13.

Air Force Cambridge Research Laboratories Exploding Wire Conference, Kenmore Hotel, Boston, Mar. 10-12.

Society for Nondestructive Testing Spring National Convention, Chapman-Park Hotel, Los Angeles, Mar. 16-19.

Pricing and Negotiating Prime and Subcontracts in the Defense and Aerospace Industries Seminar, sponsored by the Contract Management Institute, Ambassador Hotel, Los Angeles, Mar. 16-20.

NBS Symposium on Statistical Association Methods for Mechanized Documentation, National Bureau of Standards, Washington, D.C., Mar. 17-19.

Third Hypervelocity Techniques Symposium, Denver, Colo., Mar. 17-18.

IEEE International Convention, Hilton Hotel and Coliseum, New York City, Mar. 23-26.

American Meteorological Society National Conference on Physics and Dynamics of Clouds, University of Chicago, Chicago, Mar. 24-26.

Southwest Research Institute Aerospace Bearing Conference, San Antonio, Mar. 25-27.

Technical Symposium, sponsored by Polytechnic Institute of Brooklyn, IRE, AIEE, Army, Navy and Air Force, New York City, Mar. 23-Apr. 2.

APRIL

Society of Plastics Engineers, Engineering with Thermoplastics, Sheraton Hotel, Akron, Apr. 1.

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The Cost of Cost Reduction

LIKE MOTHERHOOD, cost reduction is to be devoutly regarded. But we must confess that we are disturbed by the present approach of the Administration to this admittedly desirable goal.

President Johnson, NASA Administrator Webb and Secretary of Defense McNamara have blanketed the industry with well in excess of 7,500 letters on the subject. These urge increased attention to cost reduction and ask companies to report actions taken as a result.

More recently, the Dept. of Defense has proposed guidelines for a uniform cost-reduction program. The industry's 100 largest prime contractors have been asked to comment on these. Industry firms are expected to set up cost-reduction programs or expand and intensify existing efforts along this line.

Contractors will be expected to report twice a year on performance in cutting costs. The seven pages of guidelines also include a proposed reporting form and digest of data expected.

Implicit in all of this is a picture of a missile/space industry which has been grossly negligent in holding the line on costs while fattening itself at the government trough.

This just is not true.

The Administration is acting as though this were a non-competitive industry unmotivated by a desire for profit. This is, in fact, a highly competitive industry. The contractor who lets his costs get out of hand prices himself right out of business. The profit motive remains the best cost-cutting incentive in the world.

As we have said in the past, we are pleased with the recognition DOD has given to the need for more reasonable profits. The days of companies operating government plants with government equipment on government contracts, those days when rate of return on capital investment provided a cheery contrast to apparently low profit margins, are gone. These days, the industry largely builds its own plants and furnishes its own equipment. DOD has recognized this shift with acknowledgement that more reasonable profits are required.

But the Defense Dept., and the Administration, are following an illogical course in attempting to make cost reduction a primary goal of a profit-motivated industry. Any firm can cut its cost to zero by going out of business. What must be determined are those costs which are essential to keeping the company in business.

These may be costs which the government, approaching the problem with a different philosophy, will not recognize.

Dudley E. Browne, group vice president for finance and administration of Lockheed Aircraft Corp., puts the problem well in the current issue of *The Federal Accountant:*

"Cost reduction, in industry's point of view, is good only because it leads to profit improvement. In the short term it will certainly do this. In the long term, it may or it may not. Some costs must be incurred to assure the future, such as expenditures for new machinery, or for research and development to bring forth a new product. These are costs that can maximize profits. Unlike costs that are excessive or unnecessary and hence reduce profits, costs of product improvement are those that help promote customer acceptance, more sales and more profits. And in the long run, I believe, such costs are in the best interests of government."

An intensive cost campaign by the government, forcing cost reduction on a project-by-project basis, can damage industry's ability to fund those overhead items necessary for future health. This, in time, is bound to reduce quality and increase cost to the government.

Company management cannot concern itself solely with cost on a project basis but must assess costs in terms of the full company operations. With future profits in mind, it may make decisions which are inexplicable to government auditors.

Forcing firms in the industry to build extensive cost-reporting organizations merely serves to increase administrative overhead and adds to the paper storm of blizzard proportions which already costs the government money. Less government interference, not more, is the answer.

THE ADMINISTRATION ATTEMPT to highlight cost reduction as a goal in itself will only lead clever management into artificial cost cutting or into delay of actual cost improvement which later can be billed as virtuous response to government demands.

The Administration should recognize that the free enterprise system provides in the profit motive its most potent weapon. It must recognize, not cost-reduction programs, but true cost reduction in terms of lower prices. It must leave to management the prerogative of achieving these in its own fashion.

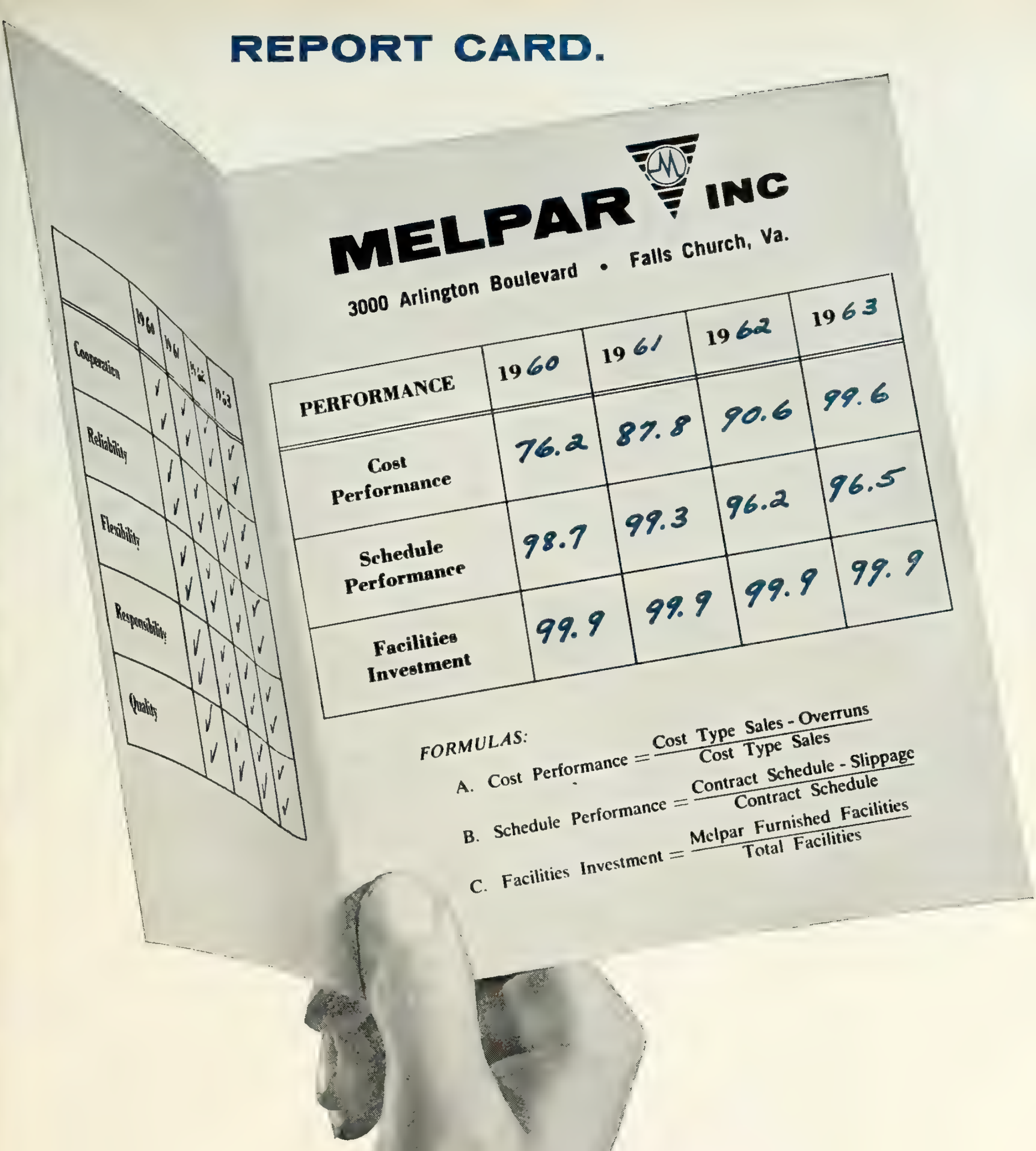
Firms in the missile/space industry long have carried out cost reduction for its own sake. In his response to President Johnson's letter, President William E. Zisch of Aerojet-General reported cost savings of $4 million in the *Titan* program and $5.5 million on *Minuteman*. These were not achieved because the President wrote a letter or because Secretary McNamara set up a cost-reduction organization. They were achieved because they were in the best interests of the company.

Mr. Browne, in pointing out that cost reduction is a means and not an end in itself, also emphasizes the important fact that the law of diminishing returns applies in this area as in so many others. As the limits of cost reduction are approached, the final gains cost more than they save. The government's new emphasis on cost reduction could push industry into that area.

The Administration should leave cost-improvement methods to industry. It can better achieve its goal by careful shopping than by imposing an additional paperwork burden.

William J. Coughlin

REPORT CARD.



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THE WEEKLY OF SPACE SYSTEMS ENGINEERING

HOUSTON

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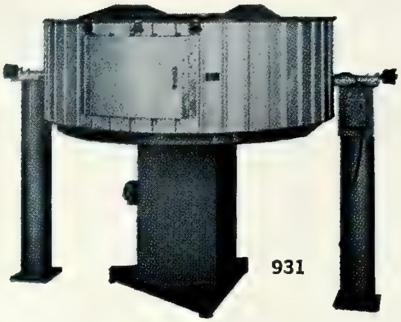
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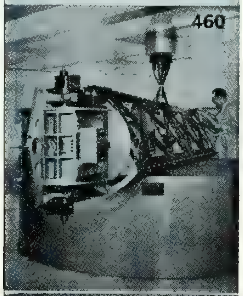
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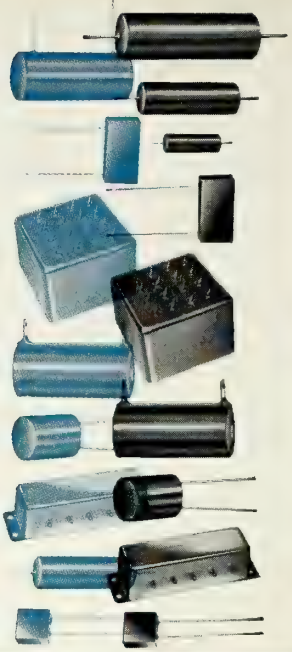

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INSTRUMENTATION NEWS

MILITARY EDITION

Number 1-MI

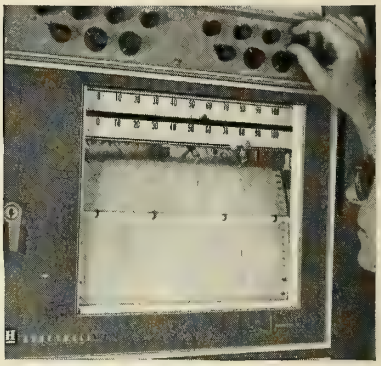
ElectroniK 16 Recorder Introduced

PHILADELPHIA — Honeywell's Philadelphia Division has introduced the *ElectroniK 16* potentiometer, a strip-chart recorder offering many standard features now optional on other recorders.

"The *ElectroniK 16's* modular design concept, along with a number of customer-oriented features that make it convenient to install, maintain and use, makes it the easiest to work with recorder on the market today," said W. A. Forsyth, military market manager for Honeywell's Industrial Products Group.

"For example, the instrument mounts directly into a 19-inch relay rack without using adapters. It has a new, high-performance, transistor servo-measuring unit. Chart-changing time has been reduced to less than a minute. And we can supply an optional pre-loaded chart transport that permits charts to be changed in approximately 10 seconds."

Mechanical layout of the recorder is such, Forsyth said, that most available options and accessories have their own unique location on the chassis. This permits the customer to later add features previously available only as factory-installed or not possible at all if certain other options also were desired.



Operator makes setting on Adjustable Range Unit, optional equipment with two-pen *ElectroniK 16* strip-chart recorder.

"All adjustments can be made simply by sliding the chassis forward," Forsyth noted. "The ink supply can be refilled so easily that the instrument's recording operation is not interrupted. The electrical span and zero controls are made entirely by precision potentiometers specifically designed by Honeywell for this function. And a new type of cam-operated backset switch has been created, again with simplicity of adjustment and stability of operation in mind."

The *ElectroniK 16* is currently available in single-pen, two-pen and multi-point models. Among the options available are an Adjustable Range Unit, chart supply indicator, retransmitting slide-wires and event markers. The multi-point recorder has an option whereby any combination of 1 to 24 inputs can be selected by positioning appropriate buttons, and another option giving plug-board selection of alarm points.

WRITE FOR COMPLETE DETAILS

Analog, Digital Data System Cuts Time, Cost for Raytheon

SUDBURY, Mass.—Data that once would have taken six technicians at Raytheon's Space and Information Systems Division here two weeks to record and plot is now being reduced in two hours by one man.

Behind this 168 to 1 time compression is an automatic Honeywell analog and digital data processing system. Designed and built as an Air Force modernization facility from standard components by Honeywell's Special Systems Division, it can record, for selective playback and readout, up to 230 channels of data from 11 remote test areas.

Raytheon lab manager Elmo Pacini checks Honeywell Model 1108 *Visicorder* oscillograph as it monitors wave shape of 24-channel vibration test data.

The analog portion of the system receives data from one shock test area and five vibration test rooms. The digital system handles temperature, barometric pressure and air flow data from five climatic environmental test chambers.

Primary inputs for the analog recording sub-system are 24 accelerometer signals, recorded simultaneously on two-inch FM tape. Wave shapes can be monitored with a Honeywell Model 1108 *Visicorder* oscillograph. Also recorded are shake table frequency, vibration servo control output and voice for a total of 27 analog channels.

The playback sub-system, using the same Honeywell tape transport as the recording network, plots rectified acceleration level vs. frequency on an X-Y plotter in log-log or log-linear form.

The digital system scans at 100 points per minute, measures, linearizes, digitizes and records up to 200 inputs from thermocouples, turbine flow meters and pressure transducers.

Information is fed into a Honeywell ADRT 3200 data logger having an incremental tape recorder. This recorder stores up to 72 hours of 200-channel data on one 2400-foot roll of half-inch tape.

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Volume 14, Number 9
March 2, 1964

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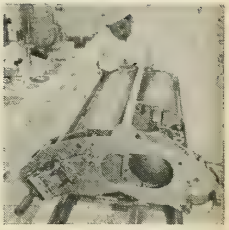

Textron Bell Aerosystem Co.'s secondary propulsion system for Agena target vehicle is shown in clean room before being shipped to Lockheed Missiles & Space Co. Each Agena target vehicle for the Gemini spacecraft will have two modules astride the Agena's aft rack. See story page 10.

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letters

JPL & Ranger (cont.)

To the Editor:

Your Feb. 10 editorial certainly takes the Jet Propulsion Laboratory to task. It's a confusing dissertation, however, alluding to the premise that either "private industry" or civil service organizations are competent in space engineering, but not non-profit organizations such as JPL. We should either pay large fees (5 to 8%), such as most contractors get, or none at all, but certainly not the ½% pittance paid to CalTech. Now what kind of sense does that make?

You suggest someone should be fired as a result of the *Ranger* failures. But are you at MISSILES AND ROCKETS consistent? Do you fire editors for lashing out irresponsibly before examining all the facts? Among those you overlooked were:

1. *Mariner II,* an outgrowth of *Ranger* and a much more complex mission, was quite successful.
2. The *Ranger VI* failure occurred in the largest single subcontracted portion of the spacecraft, built by "private industry."
3. The *Ranger* and *Mariner* programs have not had the benefit of a flight test program and have been required by NASA to be burdened down with scientific experiments from the first launch. What *Saturn* launching has had to carry scientific equipment as its primary mission? As a matter of fact, if you will look at the first six *Ranger* flights as test flights, you will see that significant progress has been made as the failures moved downstream from *Agena* to experimental payload.
4. If 100% success of *Ranger VI* had to be assured, why did NASA plan three more shots just like it?
5. Have you compared payload cost per pound or information bits per dollar for JPL, "private industry," and Government agency feats? If you had, I doubt if you would have printed your missive.
6. The so-called "private industry" in the space business isn't private at all. Most of them are using Government-owned facilities and equipment and what they do own is paid for by the taxpayers out of high fees. The closest thing we've had to private industry was Bell Labs' *Telstar.* If that's the kind of thing you had in mind, I'm all for it.

Robert P. Thompson
Glendale, Calif.

P.S. Please cancel my subscription herewith and refund the balance. I will now subscribe to a more competent technical publication.

Sand Into Space

To the Editor:

I have completed reading "SA-5 Orbit Boosts U.S. Prowess" (M/R, Feb. 3, p. 17) and was quite alarmed at the description of the orbiting package—"flying junkpile" —and especially at the last part of the sentence . . . "and 11,500 lbs. of sand ballast."

Surely, at a time such as the present when every hour of every day is important, in terms of our race with the Russians, we can make better use of a high-power rocket engine than sending 5¾ tons of sand into space. Granted that any shot during a testing phase is a gamble, actually every shot is a gamble—during or after completion of the test phase.

With the millions+ dollars being spent on the various research and development programs there must be at least one program which could have made use of the space and weight factors devoted to transporting sand into space?

Herbert E. Wodtke
Collinsville, Ill.

Electronics Research Center

To the Editor:

Your Feb. 17 editorial, "That Boston Center," has been read with great interest, and I sincerely hope that your message will be effective.

Getting the government out of business which the government has no business to be in is an absorbing interest with me . . .

Best wishes for the success of your efforts to preserve the Private Enterprise System upon which our freedom is based.

D. Hayes Murphy
Chairman
The Wiremold Company
Hartford, Conn.

Labor and Defense Costs

To the Editor:

A few weeks ago DOD sent out an impressive letter. Signed by Secretary McNamara, it urged all defense contractors to go on an austerity budget, to cut all waste, to eliminate all inefficiency. The implication was that we would now get down to business and really achieve the impossible—high-quality hardware at reasonable cost.

The first sequel to this announcement was the contract that the Teamsters signed with the trucking indusry. It was a fancy contract, with lavish fringe benefits.

The next austerity measure was taken by the steel industry, when they signed the new contract with the Steelworkers. Imagine, how efficient thirteen-week vacations are.

It appears then that austerity will be limited to those of us who are not organized into sufficiently powerful pressure groups.

More serious than that, however, is the effect on the morale of the unorganized member of industry. To be harrassed, threatened and pressured to be more productive, so that others can be less so, just is not going to do the job.

Tony Berger
Burbank, Calif.

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You can use this idea to seal doors

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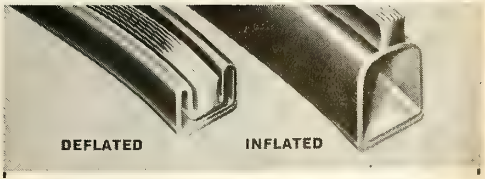

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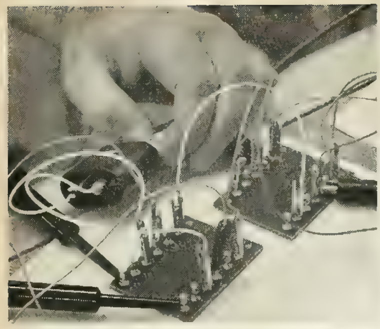

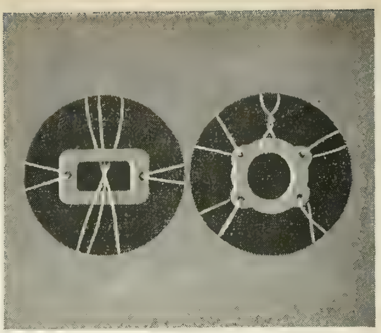

Despite the tremendous speed and ravenous appetite of today's most advanced computers, scientists at Lockheed Missiles & Space Company's Computer Research Laboratories feel that there is room for a great deal of improvement. They have dedicated themselves to the discovery and development of ways to increase the speed and reliability of computers while simplifying their operation.

Though today's computer circuits are capable of operating at speeds measured in tens of nanoseconds, the useful computation rate is far slower. One of the roadblocks hindering speed is the need for the computer to wait for the carryovers from one column of figures to catch up with the main calculation. A possible answer to this problem is modular arithmetic, which avoids carryover. Based on the ancient Chinese Remainder Theorem, this concept is being re-examined at Lockheed for potential computer applications.

Lockheed's Computer Research Laboratories are studying a very broad group of related computer research areas, and the company can boast that an unusual number of its specialists are at the very forefront of their specific fields.

Among the major areas of research being undertaken at this time are basic physical phenomena, such as phonons; quantum mechanics; switching theory; residue arithmetic (number system research); threshold logic and pattern recognition and logic design techniques.

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The Countdown

WASHINGTON

Gemini, Ranger VII Slippage Victims

First unmanned *Gemini* flight, scheduled for March, is now very likely to slip into April. Reason: delay in the recent static firing of the *Titan II* booster. Expected shutdown of the Deep Space Instrumentation Facility (DSIF) will also mean further slippage of *Ranger VII* to May or June. The tracking system will be shut down for about six weeks to tool up for the *Mariner* launch in November. Meanwhile, the *Atlas* booster set up at the Cape for the *Ranger* launch has been replaced by an *Atlas-Antares* to be used soon in a Project Fire shot.

Lance Aimed at Minimum Retraining

One of the major aims of the *Lance* development program is to minimize retraining and maintenance requirements. Army says the new system will demand "little extensive retraining" of crews familiar with *Honest John* or *Little John*. Maintenance requirements will be filled with tools already in the TO&E of operational units, with one exception—a special spanner wrench.

Program Definition of Comsat Completed

DOD has wound up the program definition phase of the military comsat program—Program 369—but its status is still up in the air. Air Force officials refuse to reveal the status of the contract with the Philco-TRW/STL team. The award was extended in December for 60 days.

Manned Planetary Flyby's Seen in Decade

NASA planners believe manned Mars and Venus flyby's are possible beginning in 1974—assuming the money is available. Landing missions could then start in 1980. One manned planetary spacecraft being studied by the space agency would weigh 340,000 lbs.

Marines Dump Honest John

Three batteries of the *Honest John* bought by the Marine Corps have been phased out and the missiles returned to the Army. The unguided rocket proved too unwieldy for the Corps' amphibious operations. It will be replaced by the Howtar—a 4.2-in. mortar and a new howitzer.

Navy Still Interested in Mauler

Although officially the Navy has dropped the *Sea Mauler* program, which would have adapted the Army's *Mauler* air-defense missile system to warships, both Army and Navy officials have made it clear the Navy's requirement in this area is not dead. Other approaches are being explored, but if the Army should solve *Mauler* development problems, the Navy is eager to adapt it.

First Spot of Trouble for Vela

At least one of the two *Very High Altitude* (formerly *Vela Hotel*) nuclear explosion detection satellites ran into its first minor difficulty about two weeks ago. Problem is believed to have been a battery failure, but it's reported a switch was made to a backup. Otherwise, performance of both satellites is described as "most unusually successful."

Congress Seeks New Thrust in Propulsion

Two or more of the House Space Subcommittees have taken NASA to task for alleged "lethargy" in its propulsion program. Congressmen are disturbed about the pace in all phases—liquid, solid and exotic—and some sort of action seems to be in the wind.

INDUSTRY

New Delta Buy Tops $9 Million

NASA will buy eight more *Delta* launch vehicles from Douglas Aircraft Co., bringing to 47 the number of these well-proven boosters it has acquired. Although the new contract, expected to exceed $9 million, doesn't cover modification, the boosters to be bought will be capable of thrust augmentation and some will be converted to *TAD's*. NASA expects to use the vehicles for orbiting *Biosatellites* and *Pioneers*, as well as future meteorological and other satellites.

New Method of Rigidizing Investigated

The Air Force Materials Laboratory has embarked on an in-house program to research a proposed chemical concept for rigidizing expandable aerospace structures after inflation in space. Study involves use of flexible coated-fibrous structural materials that will remain flexible for long storage periods in folded condition.

INTERNATIONAL

Aramis Proposed for Antiaircraft Defense

Short Brothers & Harland of Britain and Dassault and Matra of France have proposed that the *Aramis* guided missile be used to fill an alleged gap in NATO defenses. The three companies have submitted blueprints and are awaiting official approval. There's no explanation yet of the relationship of the *Aramis* mission to that of the U.S. *Hawk*.

Aussie Station To Fire Syncom Kick Motor

Australia and the United States have signed an agreement for a portable command and telemetry station at Salisbury, Australia. It will be used to fire the apogee kick motor of the *Syncom* spacecraft.

Russian Scientist Starts Cuban Station

Nikolai Yerpyiev, scientific secretary of the USSR Academy of Science, has gone to Cuba to begin setting up a satellite observation station there, Tass reports. The Soviet news agency says some equipment for the installation has already been delivered to Cuba.

Industry Due Marshall Work

Marshall Space Flight Center is shifting more of the developmental work on the *Saturn* boosters to its industrial contractors.

Principal contractors immediately affected will be Boeing Co., Chrysler Corp., International Business Machines Corp. and General Electric Co.

Boeing is now assisting Marshall with the design and engineering of the S-IC stage of *Saturn V*. The company can be expected to assume more engineering tasks as the development of the stage progresses.

Chrysler will also be given additional tasks, including work on the electrical ground support equipment for *Saturn I* and *Saturn IB* instrument console.

In addition, the two firms can be expected to increase their activity in systems engineering tasks in such areas as analysis of flight dynamics and structural analysis, advanced design, assembly and interface documentation.

Each firm will be assigned responsibility for the operation of some test facilities at Huntsville. These will include the dynamic test stands, the *Saturn I* test stand and the load test facility now under construction. Boeing will have test responsibilities also at the MSFC Mississippi Test Operations.

IBM is now under contract for the production of subsystems of the Marshall-designed instrument unit. The contract calls for eventual takeover by IBM of the responsibility for additional structural and mechanical design, procurement of components, and assembly, checkout and documentation of the entire instrument unit.

General Electric will be given the mission of design, fabrication, assembly and checkout of ground support electrical equipment for *Saturn IB* and *Saturn V*.

Medical Overlap Attacked

NASA and the Air Force are finally coming to grips with the problem of duplication in bioastronautics or aerospace medicine, NASA officials report.

Dr. George M. Knaupf, acting director of aerospace medicine in the Office of Manned Space Flight, told Congress last week that meetings last summer have resulted in an agreement by which all NASA and AF tasks in this area are jointly reviewed and assigned.

In fact, said Knaupf, the meetings have resulted in the cancellation of 55 projects—47 in the Air Force and eight in NASA. As examples, he said the Air Force had dropped studies of emergency escape and a portable life-support system, while NASA cancelled plans to study radiation damage, a cardiac output study and the development of components for two-gas environment.

Nine hundred programs in the Fiscal 1964 budget were originally reviewed, Knaupf said. Besides those cancelled, 236 Air Force and 111 NASA programs were allowed to continue, and 481 Air Force and seven NASA programs were judged peculiar to their particular agencies. Only two need further coordination at this point. In addition, 123 were turned over as being best suited to NASA's Office of Advanced Research and Technology.

DOD Briefing Dates Given

The Dept. of Defense has announced to industry the tentative schedule for seven of the 13 calendar year '64 classified briefings on its long-range development plans.

Subjects of the meetings and the dates are: Aircraft, May 25; Missiles, May 26; Electronics, May 27; Command and Control, either the fourth week of May or in June; Arms and Ammunition, second week of June; Chemical and Biological, June 15; and Nuclear Products, fourth week of June.

All the meetings, with the possible exception of the one on Arms and Ammunition—which may be in Chicago—will probably be held in Washington, D.C.

Bell Delivering Agena System

Delivery of the first module of a newly developed secondary propulsion system for the *Agena* target vehicle, which will rendezvous with the *Gemini* spacecraft, will be made this week by Textron's Bell Aerosystems Co.

The system module will be delivered to Lockheed Missiles & Space Co., Sunnyvale, Calif. It consists of a set of 16- and 200-lb.-thrust radiation-cooled rocket motors (see cover), positive expulsion propellant tanks, a pressurization system and various valves and controls needed to support each module.

Each target vehicle will have two modules that fit snugly astride the *Agena's* aft rack. The system will be used in space to re-orient the propellants for Bell's multi-restart *Agena* engine, and to make vernier adjustments to the target vehicle velocity before docking.

More 'Moonspots' Predicted

Bright red spots on the Moon that Air Force scientists at Lowell Observatory reported seeing on two different occasions late last year will possibly be seen again toward dusk on June 4 and 5.

This is the opinion of the Lowell observers, based on calculations made by Jack Green, North American Aviation, Inc., geologist.

Green is said to base his prediction on the fact that the Moon on those dates will be as close to the Earth as it can get and, simultaneously, the lunar libration will place the Aristarchus area—where the spots were seen—closest to the Earth.

Several causes are ascribed to the spots. A prevalent one is that they are luminescing gases, originally under pressure beneath the Moon's crust, but set free by fissures induced by the Earth's gravitational tug. A second possible explanation is that the spots are no more than reflected light that appears red because of Aristarchus' terrain and its position relative to the Sun at the time the sightings were made.

The work of observing the Moon is sponsored by the Air Force's Aeronautical Chart and Information Center. A spokesman for ACIC said if the efflux were truly gas, it might indicate a warm spot for astronauts to cluster during the cold lunar nights. And if the gas were hydrogen, it might have been formed by the dissociation of water, a boon to any explorers on the lunar surface.

Army Defends Lacrosse

The Army has answered charges by the General Accounting Office that it wasted $300 million on the *Lacrosse* missile system, recently replaced in Europe by the *Honest John* and 175-mm guns.

In reply to a GAO report calling the missile unsatisfactory because of inaccuracy, maintenance difficulties and susceptibility to electronic interference, the Army said the weapon nonetheless "met a critical requirement for a point target weapon."

AF Ends TRUMP Series

The Air Force reports its Target Radiation Measurement Program (TRUMP)-Interim was successfully concluded Feb. 12 at the Air Proving Ground Center at Eglin AFB, Fla.

A Proving Ground official said of the program: "We have acquired more data per dollar in TRUMP-Interim than in any other probe-borne radiation study." The TRUMP program investigated light intensity from ICBM's, particularly in the infrared and ultraviolet ranges.

A new, more sophisticated program, called TRUMP-Hitab, will be started in the near future using a different and heavier high-altitude vehicle.

Boeing Building Test Stand

The Boeing Co. has broken ground for a $1.5-million test stand capable of handling 50,000-lb.-thrust upper-stage engines.

Boeing expects the stand to be ready for use later this year. It will be the first facility built on a 100,000-acre test area Boeing recently purchased at Boardman, Ore.

24-Satellite System Studied

General Electric Co. has just completed a NASA-funded feasibility study for a global navigation and control system employing 24 satellites and six major ground stations. A report on the $100,000 study is now under review by the Communications and Navigation Programs Div. at NASA headquarters.

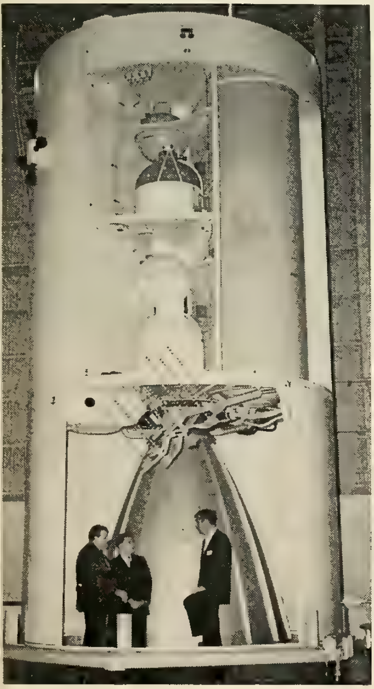
The system, as conceived by GE, would be used for aircraft and ship location, navigation and control; air-sea rescue operations; remote-area data transmission; and satellite mapping.

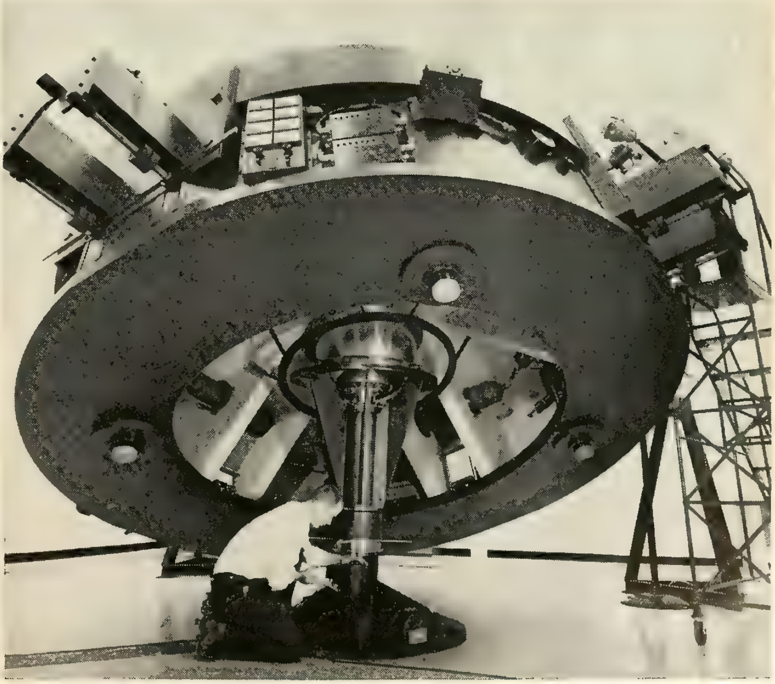
The network would deploy two dozen 150-lb. satellites, six in each of four orbital planes. They would be inclined 51 deg. to the equator with the orbits equally spaced at 90-deg. intervals. Four *Atlas-Agena* launch vehicles would be used in multiple-satellite launchings. The satellites would then drift into a semi-random pattern at about 6,500 miles altitude. Not all 24 satellites would be operated initially; hence some space-stored vehicles could be turned on when required.

The six ground stations located around the globe would provide the world-wide coverage GE says is possible with this system. Each station would work with at least two satellites simultaneously at all times, using the known position of the satellite pairs to determine the position of a transponder-equipped ship or aircraft through measurement of time delay between transmissions.

Actually, the system would operate in both passive and active modes. GE says active mode accuracies to .1 nautical mile are possible and overall position fixing to within 1 nautical mile.

A single ground station working with a pair of satellites should be able, according to GE, to receive and display up to 14,400 position fixes an hour. Equipment aboard aircraft (loop antenna, transponder, and dis-





Progress Reflected in Project Apollo

LEFT: Mockup of 25-ton Apollo Service Module shows relative positions of main rocket engine and propellant supply. The 21,900-lb.-thrust powerplant, under development by Aerojet-General Corp. for North American Aviation's Space and Information Systems Div., is more than 12 ft. from end to end, and uses a 60:1 expansion cone. Skirt fabrication involves the most extensive welding known to date in tissue-thin titanium and columbium. RIGHT: Honeywell's 9-ton simulator rides on a gas bearing in tests aimed at checking out spacecraft's stabilization and control system. Cold gas jets provide thrust.

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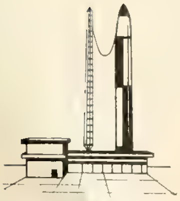

The 1021 is a versatile laboratory instrument, and can speed production testing operations.

Write for specifications and/or a demonstration. Information also available on RSE Model 1001 FM Signal Generator and RSE Models 1851 and 1853 Coders.

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play) using the system will occupy between 1-2 cu. ft. and weigh between 20-50 lbs.

The satellite envisioned would be shaped in a triangular prism configuration, which, combined with yaw stabilization (no details given except that the system requires no fuel consumption) will reportedly cut down by 50% the solar cell area required. Vertical stabilization will be by gravity gradient techniques using a de Havilland extendable rod and a GE magnetically anchored viscous damper.

The satellite would have a circularly polarized, 6-turn helical antenna, 7 in. in dia. and 30 in. long, with a ground plane gain of 12 db. Photovoltaics will supply prime power of 100 watts. The vehicle would use solid-state logic and switching nets, a 550-mc superheterodyne receiver, and 500-mc transmitter with 35 kw peak power 1 microsecond pulses.

Douglas Proposes H-F Stage

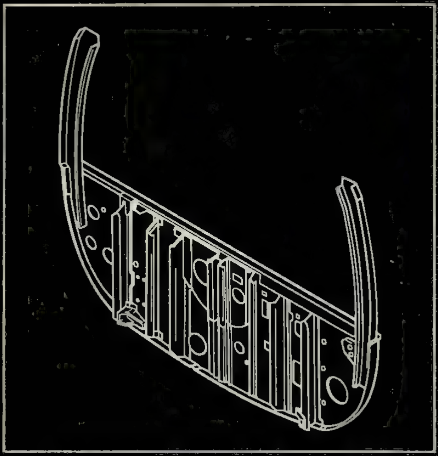
A completely new upper stage designed to add the potential of hydrogen-fluorine to the *Thor* family of boosters is being proposed to NASA by Douglas Aircraft Co. The stage could be used with all other major boosters.

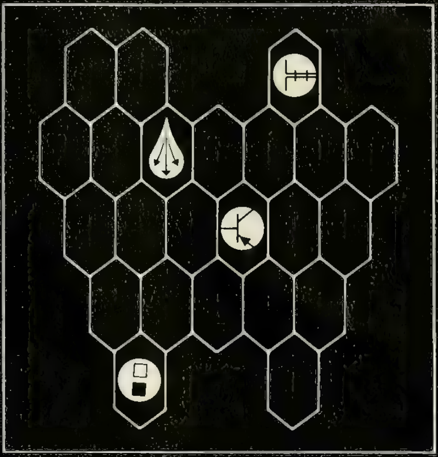
The universal upper stage would be powered by a single engine generating 35,000 lbs. thrust. The restartable vehicle would be 30 ft. long, 10 ft. across and would carry 15 tons of propellant.

Shots of the Week

The Air Force and NASA each conducted doubleheader launches last week.

- On Feb. 24, Army artillerymen lobbed two consecutive *Pershing* tactical missile shots 200 miles from Ft. Wingate, N.M., to the White Sands Missile Range as part of a training exercise. Warheads were replaced by instruments, which indicated the two firings were on target.
- The Air Force launched two *Minuteman* ICBM's within 45 minutes of each other Feb. 25 from Vandenberg AFB, Calif. The firings were to test a new nose cone of undisclosed type.
- Also from Vandenberg on Feb. 25, the Air Force fired an *Atlas-Agena* combination on an undisclosed mission.
- The Air Force launched an *Atlas* and a *Minuteman* from Cape Kennedy on Feb. 25 and a *Titan II* on the 26th. All were successful.





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Seven NATO members agree . . .

MLF Demonstration Ship Picked

McNamara announces choice of guided missile destroyer USS Biddle; U.S. envisions 25 craft with Polaris-type missiles

by James Trainor

U.S. EFFORTS to establish a multilateral NATO force (MLF) of surface ships armed with *Polaris*-type nuclear missiles moved a big step forward when Secretary of Defense Robert S. McNamara announced that a U.S. guided missile destroyer would be used in a test of the MLF's possibilities.

McNamara disclosed on Feb. 26 that the USS Biddle, normally based at Norfolk as part of the Atlantic Fleet and carrying *Tartar* antiaircraft and *Asroc* antisubmarine missiles, had been selected as a "mixed-manning demonstration ship."

He said the demonstration program had been agreed upon by the U.S. and six other NATO nations—Britain, West Germany, Italy, the Netherlands, Greece and Turkey.

A Defense Dept. announcement said it would take six months to select crew members and give them language training before assignment to the Biddle. Informed sources said foreign crewmen may ultimately comprise about 60% of the ship's complement of 18 officers and 316 men.

The Biddle will operate with its test crew with the Second Fleet in the Atlantic and the Sixth Fleet in the Mediterranean.

"The technical equipment on the Biddle will not be the same as that being considered for the surface missile vessels of the (MLF)," the Pentagon noted. "The Biddle will, however, provide operational experience with a complex weapon system."

The six months' demonstration, if successful, could lead to the development of a NATO nuclear force consisting of 25 surface ships armed with eight *Polaris* missiles each. The invulnerability of this force would be achieved by intermixing the *Polaris* armed ships with the high-density commercial shipping along the European littoral.

The ships would be armed with the *Polaris A-3* or the *MMRBM*. In fact, *MMRBM* development would be given new life by a decision to implement the MLF, according to DOD officials.

- **MLF, political balm**—Ever since MLF was first proposed by then Secretary of State Christian Herter before the ministerial conference in Paris in December, 1960, it has had an admittedly political purpose. It would give European nations of NATO a greater feeling of participation in the control of nuclear weapons, while at the same time not relinquishing U.S. control. West Germany has been particularly desirous of such a voice in nuclear matters.

Such a force would, it is hoped, achieve two major U.S. foreign policy objectives—the reunification of NATO and the prevention of national nuclear deterrent forces. Under MLF, no one nation would be able to launch the force and, presumably, by participating in the control of this force would be deterred from developing nuclear weapons of its own.

- **A first step**—The importance of the demonstration ship should not be underestimated. Part of the concern with the MLF concept, voiced particularly by the U.S. Navy, is the ability of a multinational crew to operate together.

In fact, the Navy has vetoed any consideration of a multinational crew for submarines. Many surface ships have multinational crews, however, and this is the approach to be explored.

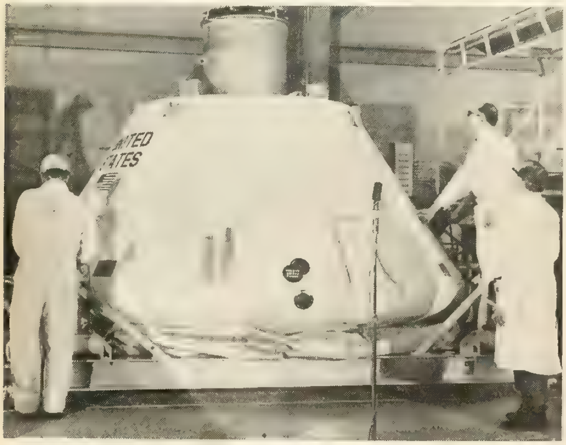
If the demonstration is successful, development of the MLF force could begin early in 1965, leading to an initial operational capability in 1968. Cost of the program has been estimated at $5 billion. However, the share for each of the nations participating in the program has been variously placed at 5-10% of the country's defense budget over a period of years.

- **Polaris base in Spain**—In another development, the Navy announced that a *Polaris* base would be established on the West coast of Spain at the Rota Naval base there. The USS Proteus will establish Squadron 16 at the base. The tender Holland will presumably replace the Proteus at Holy Loch, Scotland.

Although there are only 16 *Polaris* submarines ready for sea and only 11 of these are deployed, each *Polaris* tender is equipped to provide full base facilities and support for nine submarines, with as many as three being serviced at one time.

The USS Lafayette will be the first ship of Squadron 16. The Rota base is expected to be as big as Holy Loch as soon as the Navy gets a similar number of submarines deployed there.

Up until the time that the Rota base was announced, *Polaris* submarines operating in the Mediterranean had to use the Holy Loch base for re-supply and support. ■



First Apollo Unit at Cape

ENGINEERS and technicians inspect first Apollo Command Module to arrive at Cape Kennedy from North American Aviation. Tube protruding from top is passageway to Lunar Excursion Module.

Flying by early 1970's . . .

Improved Saturn IB Would Orbit 30 Tons

Decision on configuration due in a year or two; details of space agency plans for advanced manned space missions

by Hal Taylor

NASA EXPECTS to develop an uprated *Saturn IB* launch vehicle in time for flight in the early 1970's.

A decision on the vehicle's configuration will be made in a year or two.

Concepts under consideration include solid strap-ons for the first stage and floxing or adding high-pressure engines to the upper stage.

The solid strap-on would be smaller than the 156-in. motor being developed by the Defense Dept. Best bet appears to be the 120-in. motor being developed for the *Titan III,* but it could be smaller.

The improvement program will probably increase the launch vehicle's payload capability from 35,000 lbs. to 55,000-60,000 lbs. in Earth orbit.

• **Future missions outlined**—The first detailed blueprint of NASA plans for advanced manned spaceflight missions also revealed that:

—Some space agency officials are convinced that the agency will ultimately develop an *Orbiting Research Laboratory* for the U.S. space program. As a result, NASA is studying three possible concepts for an *Extended Apollo Spacecraft,* a *Manned Orbiting Research Laboratory* and a *Large Orbiting Research Laboratory*. It also intends to use DOD's *Manned Orbiting Laboratory (MOL)* for its early experiments and believes that *MOL* is one of the possible candidates for use as a logistics system for the *ORL.*

—Little FY '66 funding for new manned spaceflight programs is expected. Prime candidates for funding in that year are the *Apollo Lunar Logistics Systems* (*ALLS*) and the *Extended Apollo*. The major budget decisions affecting future programs, however, will be made in FY '67.

NASA's planning schedule for future missions calls for *Extended Apollo* flights in 1968, *Orbiting Research Laboratory* and lunar resupply modules in 1970, and an *Advanced Orbiting Laboratory,* maneuverable re-entry ferry, interorbit spacecraft and an orbital support facility by 1974.

—About 30 contracts for study of future manned missions will be awarded by June 30 of this year.

Details of the advanced manned mission programs were disclosed by E. Z. Gray, NASA director of the projects, and in interviews with other space agency officials.

• **Programs are tentative**—In his presentation to Congress, Gray emphasized that the programs were all in the study phase and represent possible missions which can be undertaken.

In discussing future launch vehicle programs, Gray said that "we would expect there would be an improved version of the *Saturn IB* developed when the requirements were established.

In addition to the solid strap-ons and improved upper stage, he said the inclusion of a cryogenic third stage would permit the *Saturn IB* to propel 17,000 to 22,000 lbs. to escape velocity.

"If the *Saturn IB* is to be fully utilized for its maximum capability, it should have an upper stage because we believe it will become the work horse of this weight classification of spacecraft for both Earth orbit logistic systems and also for unmanned planetary probes," he told the House Manned Space Flight subcommittee.

The *Saturn V* could also be improved by use of high-pressure engines or uprating the F-1 engine from 1.5 to 1.8 million lbs. This would permit growth of 50% in its current 90,000-lb. Earth orbit payload capability.

• **Manned spacecraft**—NASA officials said that the *Extended Apollo* spacecraft will be required for long lunar exploration stay times as well as a possible building tool leading to the Orbiting Research Laboratory.

Three concepts are currently being studied.

Concept I consists of the basic *Apollo* spacecraft with extension of its lifetime by adding more expendables to the subsystems, such as life support, electrical power stabilization and propulsion.

Concept II would take the basic *Apollo* spacecraft and add to it a module for providing an expanded working area. This module would be a simple enclosure, and the subsystems required to support it would be in the *Apollo* command and service modules.

Concept III adds a mission module in the Lunar Excursion Module area. The mission module has its own subsystems so that the *Apollo* spacecraft then becomes merely a short-time ferry vehicle.

• **Apollo as building block**—"We believe the *Apollo* is a very useful kind of an early space station because it has greater flexibility in many respects than the *MOL.* For instance, for returning cargo from space, and also since it's designed for higher re-entry speed, it will be useful for exploration to higher orbits than could be accomplished with a *Gemini-B,*" Gray said.

After the *Extended Apollo,* Gray said, the space agency is looking at the *Orbiting Research Laboratory* concept.

"Beyond the *ORL,* we predict a possible growth to an advanced orbiting research laboratory with a maneuverable re-entry ferry system and also interorbit spacecraft for maneuvering within space," he said.

These systems might also be part of an orbital support facility that could be used for orbit staging for planetary exploration spacecraft. These operations would include joining together spacecraft, refueling them and maintenance and checkout operations.

"In general, we believe that an orbiting laboratory in which NASA is interested will be characterized by a great flexibility of usage," Gray said.

"It will be much like a research facility on Earth wherein you have basically a housekeeping function and then attached to it will be various kinds of scientific mission modules," he concluded. ■

Funds still lacking . . .

NASA Plans Variety of Apollo Backup Systems

NASA IS READY to start work on a number of backup systems for the *Apollo* spacecraft, including a new 125-ft. parachute to ensure safe landing if the three main chutes fail to deploy.

Dr. George Mueller, manned space-flight chief for the space agency, told M/R that a group in headquarters and at the centers is looking at a number of larger subsystems, although it has not completely defined which to pursue.

The group also favors studying alternate systems for portions of the reaction control system, subsystems in the guidance and navigation system, subsystems in the communications equipment and actual internal mechanical structures.

Mueller said that in addition to these studies NASA is carrying on a level of basic work not really identified with particular systems. Also, he indicated, the Manned Space Flight Office is looking at the entire program to identify where problems might lie. Almost all the actual work will be contracted out.

- **Supplemental hopes**—Initiation of this work, which does not come out of spacecraft funds, but rather out of "*Apollo* supporting technology," is being held up by the supplemental appropriations request. NASA's hopes for this request were dimmed slightly recently when Chairman Clarence Cannon (D-Mo.) of the House Appropriations Committee changed the manner in which it would normally have been handled.

Cannon—avowedly frugal and against the automatic passing of supplemental bills—disbanded a subcommittee which in previous years had handled only the supplemental requests. Thus, the supplemental will be considered by the Independent Offices Subcommittee at the same time it meets to consider Fiscal Year 1965 funds. Even though the House Science and Astronautics Committee is aiming at getting the FY '65 authorization bill into full committee by March 15 and onto the House floor by April 1, this still is late in the fiscal year for supplementary 1964 funds.

- **Electronics Center**—The Senate Space Committee has elected to wait until the week of March 9 before making any decisions on whether to veto the proposed Boston Electronics Research Center. According to committee sources, a number of states have asked permission to address themselves to the report, and the committee therefore promised to receive any comments from anyone interested before the 45-day period of grace is up.

The Senate committee begins hearings this week on the FY '65 authorization bill.

The House Space Committee eked out an approving vote last week—ending up 18-13. The balance had teeter-tottered since the consideration period began, but apparently was swung by Chairman George Miller (D-Calif). Dissenting votes were cast predominantly by Republicans and some midwestern Democrats, including Rep. Joseph Karth (D-Minn.), whose Space Sciences Subcommittee originally handled the authorization request for the center.

In another development, Chairman Olin Teague (D-Tex.) of the Manned Space Flight Subcommittee, voiced considerable concern as to whether NASA is making use of payload capability in the early *Saturn* tests. He said that the "load of sand" on *Saturn SA-5* bothered the committee, which has asked for a listing of specific experiments to be put on the boosters.

Mueller told M/R it is unlikely NASA will try to add any other experiments other than the micrometeoroid satellite in the early tests. "Only a small amount of space would be available, if that," he said. ■

Senate Doubles House Cut in MMRBM Budget

FURTHER BLOWS have been dealt to the *Mobile Medium Range Ballistic Missile* by the Senate Armed Services Committee, virtually assuring its suspension as a system for this year at least.

The committee, chaired by Sen. Richard B. Russell (D-Ga.) specified that $70 million be cut from the budget request of $110 million, leaving only $40 million for FY '65. This, it said, should be used for continued development of the Stellar Inertial Guidance System (STINGS), which "could be useful in connection with succeeding generations of ballistic missiles."

The *MMRBM* cut was the only specific slash in the bill, which otherwise applied a 3% reduction in all RDT&E, to be programmed by DOD.

The reduction exactly doubled an earlier $35-million cut by the House (M/R, Feb. 17, p. 14).

The Air Force just last week reaffirmed its strong belief in the missile system, saying that it expected to release *MMRBM* into Phase II within a month. Maj. Gen. W. A. Davis, commander of Ballistic Missile Division, said in Los Angeles that initial operational units could be out in 1968. It is believed that DOD could approve Phase II contracts, since this money was provided in FY '64 budget. However, the outcome now is uncertain.

Davis indicated that even if the possibility of deploying *MMRBM* in European nations is ruled out by budget cuts, the Air Force would push for development for domestic use in the composite air strike force.

Although the Senate committee did not specify where other cuts should be made, it did say that a predicted management improvement in the exploratory development category would permit a substantial part of the reductions to be applied here.

The Senate's $17,040,140,000 bill thus is $125 million more than the House bill, and $145 million less than the DOD request. Like the House, the Senate committee passed the $10,613,300,000 procurement portion intact.

Four contractor teams . . .

First Contracts Let for U.S. Standardized Space Guidance System

by Charles D. LaFond

OVER $2 MILLION has been allotted to what really amounts to a preprogram definition phase for the vaunted U.S. Standardized Space Guidance System (SSGS). Completion of the definition phase may require another $4-8 million.

As the program now stands, four contractors have been selected for Phase IA. These include the following teams: IBM/Nortronics—$700,000 (Martin, a part of this team, will provide GSE and human factors support on any follow-on contracts); Space Technology Laboratories/General Precision Inc./Univac Div., Sperry Rand—$380,000; Sperry Gyroscope/Univac Div./Kollsman Corp.—$726,711; North American Aviation (Space and Information Systems Div. and Autonetics Div.)—$300,000. This amounts to total contract expenditures of $2,106,711.

Contracts call for delivery of preprogram definition studies covering space guidance requirements through 1970, determination of overall requirements and necessary experiments to provide an all-purpose space guidance and navigation system. Contracts were awarded Jan. 29 and are due for completion within four months.

The Air Force first requested proposals from 22 U.S. firms early in September. Following these requests, a briefing was held on Sept. 24 for prospective bidders on the program definition phase.

At that time, proposals were expected to fall into the $300-350,000 range. It is interesting to note the two distinct values for the existing four contracts resulted. The IBM and Sperry teams' contracts are nearly double those of the other two. Inquiries by MISSILES AND ROCKETS have not established a significant difference in work scope among contractors, but it is obvious that a difference must exist.

Phase IB of the program calls for a feasibility demonstration, will involve open bidding, and will result in the selection of two contractors who will perform 8-month contracts. The value of these contracts is expected to fall somewhere between $2 and $4 million dollars each.

Phase II of the program will follow shortly thereafter. It will involve a complete hardware development and flight-test program, and will call for only one contractor. The value of that contract is not yet known.

- **Team efforts**—At present, it appears the contractors listed above were selected in the order presented. In the first team, IBM will provide management control and develop the computer; Nortronics will develop the inertial platform and tracker. STL will manage a team in which GPI will develop a platform and tracker and Univac will develop the computer. In the third team, Sperry Gyroscope will provide overall direction and develop the platform, Univac will develop the computer, and Kollsman will produce the tracker. The fourth team, centered at North American Aviation, consists of the Space and Information Systems Div. and Autonetics Div., who will provide system management and platform-computer-tracker development, respectively.

In its recent announcement of awards of contracts to the four contractors, AF Systems Command's Space Systems Div. in Los Angeles indicated it will direct the program for SSGS development. The system, said SSD, will be designed to handle all expected future space missions through the early 1970's. Inherent in this approach is an Air Force expectation that such a system will reduce guidance and navigation costs and produce a general-purpose G&N system.

The Phase IA portion of the program, AFSC said, will be analytical in nature to determine system configurations. Means for developing these concepts into operable systems will be studied in Phase IB. AFSC stressed that Phase IB source selection will again be open to industry-wide competition and, of course, will be based on Phase IA results.

- **Broad potential**—First word of the anticipated SSGS was revealed by M/R early in September (Sept. 9, p. 16). Even at that time it was known that this might well be potentially the largest single space guidance and navigation system development ever initiated by the Dept. of Defense.

However, tempering this is the fact that another potential SSGS now exists. And its existence has not been promoted by the Dept. of Defense.

The *Titan II* guidance system developed by AC Spark Plug Div. of General Motors Corp. apparently has proved itself. With simple modifications, the *Titan II* guidance system was turned into that used by the *Titan III* space booster.

Rumors are now rampant throughout industry that AC Spark stands a good chance of being selected eventually to supply another modification of the *Titan II* guidance system for *Centaur*. It is known that a design team last Monday visited General Dynamics/Convair in San Bernardino to discuss the possibility of employing the system in *Centaur*.

If the AC Spark system were selected, this would in fact—by attrition—make it the standardized space guidance system for the present.

- **System concepts**—DOD approved Air Force initiation of the program last fall. As then conceived, the program was aimed at developing a single system capable of providing guidance and control for space launch vehicles, orbital injection, and all mission performance requirements through the early '70's. Thus, in effect, the Air Force will attempt for guidance what it had already done for general space boosters with the *Titan III* booster system.

Inherent in this approach is the mating of the SSGS with *Titan III* systems. The new guidance and navigation system must provide a capability for space systems, space shuttle, satellite inspection, deep-space employment, orbital bombardment, general reconnaissance and deep zonal penetration above the Earth's surface. ■

Nine experiments planned . . .

Modified X-15 May Carry Ramjet

SPACE AGENCY OFFICIALS are expected to approve in the near future a program to develop a ramjet engine for flight on the *X-15* rocket plane.

The project is a major step leading to the *Aerospace Plane,* which would be launched from Earth, go into orbit and then return.

The ramjet—an air-breathing engine capable of hypersonic speed—is the most likely propulsion system for the plane.

Space agency officials disclosed to MISSILES AND ROCKETS that a favorable decision on the program is expected in about a month.

While refusing to discuss technical details, they said that they hope to fly the ramjet by mid-1967 or early 1968.

- **Study contracts pending**—Present plans call for two to four study contracts to be awarded as soon as a decision is made. It is estimated a year of research will be required to determine the ramjet's final design. Industry competition would then be held to select a prime contractor.

The ramjet would be flown as part of an extended research program for the *X-15,* which NASA said will extend the rocket plane program to 1968.

The ramjet would be hung underneath *X-15A-2*. The plane would be launched from a B-52. After burn-out of the plane's engines, the ramjet would be ignited.

The program is currently being prepared for headquarters approval by officials at Langley Research Center.

This could mean that Langley will have technical direction of the project.

- **Nine new experiments**—In announcing the new *X-15* research program, the space agency said that nine new experiments have been added to its missions, including such areas as stellar photography, advanced structures and materials, aerodynamics and data systems, and ramjet propulsion.

NASA said that structures research has been limited in the *X-15* program to date because no provisions were made on the original planes for significantly changing the structure or instrumentation. The outboard half of the right wing of the *X-15A-2* has been made detachable, and plans are to test wing tips made of titanium, columbium and other materials and their alloys, using advanced fabrication and structural techniques.

Preparation of an advanced integrated flight data system is under way, and the unit will be flown in a NASA F5D airplane at the Flight Research Center before it is installed and flown in the *X-15* next summer. Other tests will be made with deceleration devices that could be useful on advanced spacecraft as well as airplanes.

Work on equipment for ultraviolet photography of the stars has been completed on *X-15A-2,* and will be carried aloft after that plane is ready for flight. The star study, devised for NASA's Office of Space Science and Applications, under contract to the University of Wisconsin, will begin next fall.

The equipment will obtain ultraviolet photographs of the stars from altitudes above 40 miles, as a means of testing theories pertaining to their origin and makeup.

- **Star tracker hardware**—Instrumentation for the star tracker consists of a gimbaled platform containing four cameras (photometers), to be mounted in the instrumentation bay behind the cockpit. Clamshell doors atop the airplane will be opened as the aircraft arches over its long ballistic flight path and is positioned by its pilot for a clear view of the selected stars. It will be possible to make a continuous series of photographs in different ultraviolet wavelengths.

The star tracking system is slated for use later in NASA's observatory satellite program.

An alphatron ionization gage will also be mounted in a small wingtip pod for density measurements of the atmosphere above 100,000 ft., and a similar pod will house equipment for obtaining micrometeorites. Other experiments will investigate infrared and ultraviolet data for the Air Force at the extremes of the *X-15's* higher altitude capabilities.

The research program will also involve evaluation of advanced vehicle systems and structural materials. The Air Force will test an advanced integrated flight data system that will enable the pilot to plan his landing approach rapidly from re-entry to touchdown on the ground. ■

NORTH AMERICAN AVIATION'S X-15A-2 shown before being turned over to NASA at Edwards Air Force Base, Calif. The new version of the rocket plane is designed to fly at Mach 8. Modifications include external fuel tanks, a pressurized helium system for use with ramjet tests scheduled for future and a new three-paneled windshield capable of withstanding temperatures up to 2,400°F.

Air Force Investigating Cardiovascular Effects of Zero-G

by Heather David

A FOUR-WEEK bed-rest experiment is now under way under direction of the School of Aerospace Medicine to gather baseline data on what happens to the human circulatory system subjected to a situation analogous to weightlessness for the time period of the *Manned Orbital Laboratory* mission.

Air Force scientists have found several methods that could protect astronauts from the cardiovascular complications caused by weightlessness.

Space medical experts have been especially interested in this aspect of spaceflight since the postflight physiological experiences of astronauts Walter Schirra and Gordon Cooper. Schirra evidenced pooling of the blood in the legs and Cooper nearly fainted upon egress from the capsule onto the recovery ship. Both experienced a rise in heart rate and fall in blood pressure.

The symptoms persisted for between seven and 19 hours after landing and were, according to the *MA-9* official report, of "greater magnitude following the 34-hour flight than those following the 9-hour flight."

The physician's concern is, of course, the re-entry period. While the condition is an adaptation to the state of weightlessness, it becomes an impairment in the return to gravity.

During the current experiment, the subjects will be tested on their ability to tolerate the levels of transverse-g that *Apollo* and *Gemini* astronauts must sustain. Other tests will be conducted on tolerance to positive-g (headward), tendency to faint during feet-down position on the tilt table, and the efficiency of an anti-g suit in preventing fainting on the tilt table after four weeks of bed rest.

After this series, SAM doctors will study the promising preventive measures. On the basis of earlier research, Maj. Perry B. Miller, Dr. Bryce O. Hartman, and Lt. Col. Robert L. Johnson say these measures look promising:

—Frequent daily head-down and feet-down testing on a tilt table prior to prolonged bed rest.

—Use of a periodically inflated blood pressure cuff in the extremities during the flight. This might counteract the effect of weightlessness. It would increase pressure in the veins, producing the same increase as gravity.

—Periodic valsalva maneuvers, in which the individual under test exhales forcefully with his mouth closed. The increased chest pressure impedes the flow of blood to the heart, triggering a reflex that speeds up the heart and constricts the blood vessels in various parts of the body. This maintains the blood pressure.

—Intensive in-bed exercises. Whether exercises benefit the cardiovascular system, the researchers point out, they most certainly will be needed for the astronaut's general well-being.

Researchers also found that an anti-g suit provides a high degree of compensation against cardiovascular reactions when used after prolonged bed rest. However, SAM doctors say that this constitutes treatment of a disorder that might be prevented. Also, if the suit failed, and the astronaut landed in a remote area, the result would be disastrous.

- **AF studies**—These preliminary indications came out of a study in which 72 airmen 17 to 23 years old participated as subjects in an attempt to solve the cardiovascular problems.

The subjects were divided into groups of six, all of which followed a 14-week schedule consisting of two weeks ambulation, two weeks bed-rest, four weeks ambulation, two weeks bed-rest, and four weeks ambulation. All but two subjects completed this regimen, the latter dropping out for psychosomatic reasons.

- **Seriousness of problem**—Physicians had predicted the Schirra and Cooper problem, and they are very concerned about what will happen under prolonged weightlessness. It is perhaps this problem, more than that of muscle atrophy or the loss of bone calcium, that is causing physicians to worry about whether artificial gravity might have to be provided.

As NASA said in the *MA-9* report: "the implications of this hemodynamic response will have to be given very serious consideration as longer missions are undertaken. No other clearly significant changes have been found in comprehensive preflight and postflight physical examinations." ■

Study Says 30-Day Orbiting Crew Needs 198 Cu. Ft. Work Space

General Dynamics/Astronautics engineers testing out various space station configurations say their studies indicate three men could live for 30 days in a laboratory only 9⅔ ft. in diameter and 7 ft. high.

The researchers, who conducted a number of tests with pressure suits, said they could fit all the life-support and mission equipment for three men in the 72-sq.-ft. floor space. Total volume of the simulated spacecraft would be 504 cu. ft., but after equipment was installed, the interior volume was reduced to 382 cu. ft. Actual functional volume, they said, would only be 198 cu. ft.

Checks were made to determine how much pressure suits restrict operation, on how much room is needed for crew functions and whether the members interfere with one another, and how emergency conditions that require full pressurization and back-pack affected interaction.

The test subjects said they did not feel the space was adequate for longer periods than 30 days, although a 156-in.-dia. chamber might be. The three engineers did not attempt any long duration tests in the chamber.

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Photo taken at Aquarama, Philadelphia

Dolphin spoken here? The time may not be far away. Already at Sperry we have developed a tiny computer—the SCEPTRON™ Pattern Recognizer—which can memorize, distinguish between and react to different sights and sounds. In the foreseeable future such a device may be able to translate the language of, say, the dolphin (a particularly smart mammal) into human terms, and vice-versa—thereby establishing a crude intercommunication. What a world of understanding and knowledge might open up. □ The SCEPTRON—a "brain cell" of tiny optic fibers—is a product of Sperry research, which has also produced Loran-C, the rotation rate ring laser, the photoparametric diode, "heads up" windshield display for aircraft, fluid sphere and tube gyros and other technical advances. *General Offices: Great Neck, New York.*

SPERRY

DIVISIONS OF
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CORPORATION

Technical Countdown

ELECTRONICS

Monolithic/Multichip Integration Proposed

A Bell Telephone Laboratory scientist, reporting to the Solid-State Circuits Conference in Philadelphia last week, disclosed a new method for integrating devices, which combines, in a silicon mosaic, the monolithic and multichip approaches. A silicon ingot is first sawed lengthwise into slabs. The exposed surfaces are polished, oxidized and vapor-coated with germania. Slabs are stacked and oven-heated so that the germania melts, bonding the slabs. A second set of saw cuts is made perpendicular to the first, also using germania to hold the slabs together. BTL says the resistivity of each resulting checker can be different and that some flexibility in size and shape of elements is possible. N-type expitaxial silicon resistive film has been deposited on the mosaic, and expitaxial diodes and transistors were also fabricated.

Thin-Film Scan Generator Successful

RCA scientists have reported successful operation of a completely integrated 30-stage thin-film scan generator, employing insulated-gate field-effect thin-film transistors as the active element. RCA told Solid-State Circuits conferees that the generator contains 180 active and passive components, deposited over an area of 0.15 sq. in. RCA, which maintains a heavy research effort in FET's (M/R, Feb. 3, pp. 44, 52), sees the scanner operation as highly encouraging for the future of thin-film active elements. All components except the semiconductor are evaporation-deposited with a single pump-down of the vacuum system. Polycrystalline cadmium sulfide is deposited during a preliminary evaporation, serving as the semiconductor and the photosensitive elements for the image pick-up.

Cooling Improves Photodiode

Texas Instruments engineers have reported observing a large signal gain effect at avalanche breakdown voltages in both planar and mesa silicon photodiodes. An S/N ratio improvement of 5 db. has been measured at 1.25 gc. Further improvement for some devices, regardless of frequency, would result if the photodiode were cooled to very low temperatures. TI's K. M. Johnson, reporting at the Solid-State Circuits Conference, says that action of these devices may be analogous to a multiplier phototube, and, if effectively utilized, could result in nearly the most sensitive, high-frequency detector of modulated light available, being perhaps better than 20 db. more sensitive than other available devices.

Tenfold Laser Power Increase Seen

In a review of P-N junction lasers presented at the Solid-State Circuit Conference, R. N. Hall of General Electric Co.'s Research Lab predicted that factor-of-ten increases in both the CW and peak power outputs of current devices reasonably can be expected within the next two years. Hall noted that power outputs of several watts under CW conditions and nearly 1 kw during short pulses have been reported with gas lasers. Hall also said that junction lasers appear to be capable of delivering pulses of several millijoules. The generation of coherent radiation at wavelengths shorter than 6,400 Angstroms using junction lasers, according to the scientist, appears to be unlikely due to lack of any known direct transition semiconductor with a sufficiently large energy gap. On the other hand, he notes, extension to longer wavelengths may be possible, making use of small energy gap semiconductors, such as PbSe or Bi_2Te_3.

Lab-Sized 100-Kilogauss Magnet Perfected

Westinghouse engineers are operating the first superconducting magnet to repeatedly achieve fields of 100 kilogauss. The magnet is about 7 in. across and 6 in. long with a ⅛-in. hole through the center of the inside section. The high magnetic field is generated in this small hole after the entire unit is cooled in a bath of liquid helium. The unit has been cycled repeatedly from full strength to zero field without damage. Part of the tests included repeated collapsing of the magnetic field—releasing and dissipating the tremendous energy stored in the coil. The magnet is based on a new superconducting niobium-titanium alloy developed by Westinghouse. The unit is hailed by researchers as the forerunner of practical, working 100 kilogauss magnets.

MATERIALS

Superior Markets TD Nickel Tubing

Thorium-dispersed nickel tubing in restricted sizes is available on a limited basis from Superior Tube Co., Norristown, Pa. The TD Nickel—2% thoria, 98% nickel—was developed by E. I. Du Pont de Nemours & Co. and consists of a highly uniform distribution of thoria particles in the nickel matrix. The material has an ultimate tensile strength of 10,000 psi at 2,400 F. In the 1,900 to 2,300° F range, its mechanical properties better those of many nickel and cobalt-base superalloys. Superior TD Nickel tubing is a development product produced in a range of sizes under a ⅝-in. OD. An order for a given OD/wall combination will be reviewed before production and tolerances greater than commercial specifications require consultation with the mill.

Infiltrated Nozzles for Polaris A3

Silver-infiltrated tungsten nozzle components are being supplied to Aerojet-General subcontractors by Firth Sterling Inc. under a $474,000 contract. The infiltrated tungsten, called Sil-Tung, provides both a heat sink and a transpiration cooling effect in high temperature applications. The components are to be used in nozzle assemblies for the *Polaris* missile.

X-15A-2 Windows Modified

The windows in the advanced *X-15A-2* rocket plane will have three instead of two panels and be elliptical in shape instead of trapezoidal. An outer panel of 0.650 mm-thick fused silica, capable of withstanding 2,400° F, was added by Corning Glass Works to increase heat and shock protection. The change in shape lends itself to a more uniform distribution of the loads produced by thermal stresses.

Refractory-Coated Beryllium Oxide Marketed

Dense, pure, spherical beryllium oxide grain and powder, plain or coated with tungsten, molybdenum or other refractories is in commercial production at National Beryllia Corp. Compacted ceramic bodies of tungsten-coated beryllia microspheres have withstood repeated thermal shock cycling from 4,500° F with minimum damage, say NBC spokesmen. Coating thickness can be precisely controlled.

Joint Committee Raps DOD, AEC

Defense Dept. comes under fire for vacillating on needs for space-power systems; Holifield, Price lead attack

by William Beller

THE JOINT COMMITTEE on Atomic Energy in hearings last week lashed out at the "on-again, off-again" tactics of the Defense Dept. in setting up requirements for nuclear space-power units.

The Committee also took the AEC to task for not pursuing its projects to a logical end, independent of user requirements, if necessary. The AEC was specifically criticized for not pushing strongly enough for a flight test of the SNAP-10A nuclear reactor for space applications, especially after the Government will have spent about $100 million to bring it to the flight-test stage.

"I feel 10A would be used almost immediately if (a successful) flight test is attained," said Rep. Chet Holifield (D.-Calif.), Joint Committee vice chairman.

Following Holifield's lead, Rep. Melvin Price (D.-Ill.) decried the lack of a firm military requirement for Pluto, the AEC program to develop a nuclear ramjet reactor that could be the heat source in an unmanned ramjet aircraft propulsion system. He said this system could be used in the follow-on to *Polaris.*

The Air Force's recent withdrawal of requirements for flight-testing SNAP-10A and SNAP-2 was the immediate cause of the Committee's ire. Nevertheless, it was tacitly understood during the hearings that the Bureau of the Budget was pulling all the strings. It was for this reason that Holifield released a letter he had sent on Feb. 15 to Kermit Gordon, director of the Bureau of the Budget.

Pointing out that the SNAP-10A device could be ready for flight test in March-April, 1965, Holifield wrote, "the estimated total cost of this flight test is $12.4 million for FY '65, over and above funds previously approved by the Bureau of the Budget for this program." The Congressman recommended that the AEC be permitted to transfer this amount from other AEC projects, thereby staying within the agency's FY '65 budget.

- **A first for the U.S.**—The SNAP-10A system could give the United States its only opportunity to put a 1-kilowatt power source into orbit this decade. The basic SNAP-10A system—a 0.5-kwe powerplant, consisting of a uranium-zirconium hydride reactor coupled with a thermoelectric power converter—can be upgraded to a power range of several electrical kilowatts.

The recently cancelled SNAP-2 system uses the SNAP-10A reactor in a Rankine cycle. SNAP-2 was designed for a power level of 3 kwe, with growth potential to 10 kwe.

Both SNAP units were initiated on the basis of Air Force requirements, SNAP-10A in 1960 and SNAP-2 in 1956. Plans called for flight-testing 10A first, and SNAP-2 a year later.

In mid-1963, the Air Force indicated there might not be a mission for the SNAP units; later in the year, the service formally cancelled the requirements for flight-testing them. Since the original missions for SNAP-10A and SNAP-2 were classified, there was no way to learn the precise reasons for the cancellation. An AEC spokesman assured MISSILES AND ROCKETS that, at the time of the cancellation, SNAP-10A and SNAP-2 were in "good shape," technically and financially.

- **Challenges Budget Bureau**—The Joint Committee left no doubt during last week's hearings that it is pushing for flight-testing, not only SNAP-10A, but also any other SNAP units close to a demonstration stage, with or without user requirements.

Sen. John O. Pastore (D.-R.I.), Joint Committee chairman, and Rep. Holifield released a strongly worded, jointly signed letter they had sent to the Bureau of the Budget, NASA and the AEC last month (M/R, Feb. 17, p. 14).

"It is our intention," the letter said, "to include authority for the AEC to flight test SNAP-10A and to authorize appropriation of the required funds to accomplish this objective." The letter

POSSIBLE SNAP REACTOR APPLICATIONS

	Est. Use Date	Power KWe	Specific Weight Lbs/KWe	Life & Reliability
UNMANNED APPLICATIONS				
Meteorological Satellites	1966-67	2	Not critical	Important
Communications Satellites				
Synchronous Pt. to Pt.	1968-70	10	Important	Important
Synchronous T.V. Broadcast	1970-72	60	Important	Important
Military	—	—	—	—
Military Reconnaissance & Surveillance	—	—	—	—
Interplanetary Missions (Electric Propulsion)	ca.1975	500-1000	25-30	Vital
MANNED APPLICATIONS				
Manned Orbiting Laboratory	—	—	—	—
Large Space Station	ca.1975	30	Important	Important
Lunar Base	ca.1980	30-300	Important	Vital
Flight to Mars	ca.1980	20-200MWe	10-15	Vital

added, “We are advising you of our intention at this early date in order that . . . you may take effective action to prepare for this step. . . .”

The Joint Committee chairmen stated reasons for their “firm opinion”:

—the SNAP-10A reactor system has been developed to the point where flight test is needed to prove it out;

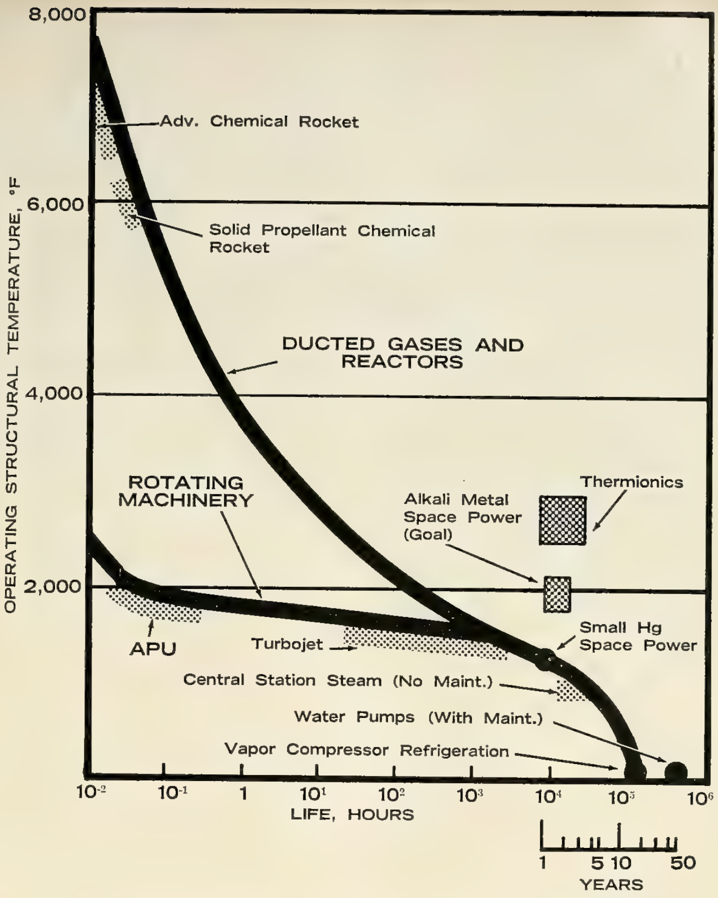
—the test would involve the first operation of a nuclear reactor in space by any nation;

—the SNAP-10A is designed to be a useful power supply for space missions and its test will provide guidance for the development of future, more advanced systems;

—a test in the environment that SNAP-10A was designed for—outer space—is needed to conclusively demonstrate the value and superiority of nuclear power for future space missions;

—extensive calculations have been made of the effects of space environment on nuclear reactors in space. Certain of these effects, such as radiation and attack by micrometeoroids, cannot be simulated on the ground.

- **Flight tests essential**—In an evaluation of the entire SNAP program, which was also released during the hearings, the AEC stressed the need for technical data that ground tests cannot give. These include “orbital startup, zero-gravity effects, effectiveness of shadow-shield design, and self-welding in space.”



MAXIMUM OPERATING temperature vs. life for power equipment.

Of transcending importance is the question of the value of a space power system based on the Rankine cycle. Even though the AEC is relying on this cycle in its advanced reactor programs, such as SNAP-50, such a cycle may not be as efficient in space as on Earth. In this event, a major change to another power conversion cycle may be necessary.

Recognizing this possibility, the AEC affirmed “It is possible that too much emphasis is being placed on the Rankine cycle before feasibility demonstration has been made in actual flight.”

- **Polaris follow-on**—Pluto was the second major nuclear system sticking in the craw of the Joint Committee during current hearings. Because of lack of a DOD requirement and the possibility that, as a consequence, the entire program might eventually be put on the shelf, Rep. Price said DOD’s action and attitude do not square with each other. The military does indeed want a low-altitude supersonic penetrating vehicle, he said. “They do have a requirement for it. . . . They have stated it (over the years) many times before the Armed Services Committees of both houses.”

Testifying on this subject, Col. J. E. Duvall, chief of nuclear power division in the office of Air Force deputy chief of staff (R&D), admitted that Pluto could possibly lead to the follow-on to *Polaris*. Duvall added that the evaluation of the service’s low-altitude supersonic vehicle—LASV, formerly SLAM—will not be out until the spring, when the Air Force is expected to make a recommendation.

The Air Force spokesman said there is not even the certainty the vehicle will be nuclear-powered. Last year the Air Force began considering chemical power for LASV.

It is estimated that by the end of Fiscal 1965, the AEC will have spent $148 million on Pluto, and the Air Force about $70 million on LASV. Even so, the AEC said it was reluctant to pour money into the flight test of Tory IIC—a reactor for Pluto—without “a real military requirement.” The Air Force estimated that a modest flight test of Tory IIC would cost between $100 and $200 million.

- **Tory evolution**—The Tory IIC reactor is a step between an engineering test reactor and a flyable prototype. During the first half of last year, the Tory IIC reactor was assembled, and criticality tests were initiated in July. Late last month, the reactor was shipped to the Nevada Test Site for further tests and a blowdown in May.

Under prodding by Holifield, the AEC conceded that if the May tests are successful, the next logical step would be to test-fly Tory IIC. The admission was made with reservations, though; given a choice, the AEC indicated it would prefer to flight-test Tory III, an advanced version of Tory IIC.

Encouragement for a test of either Tory must come from the level of the director of DDR&E “at the very least,” Holifield observed. “Despite budgetary pressure, it seems a shame to go as far as we have and drop the project. It (can contribute) to the only new weapon system we have now on the horizon.”

The AEC, seemingly undismayed by lack of missions for its snap reactor-type units, testified it would continue to develop the supporting technology to cover the power spectrum where “potential” needs exist. The agency believes that in this manner, it may someday attract a buyer. ■

Philco Labs Developing Protein Detector to Probe for Life on Mars

NEWPORT BEACH, CALIF.—An instrument for detecting traces of macromolecules on the surface of Mars, as evidence of life there, is under development at Philco Research Laboratories.

It can be designed for hard landing in a capsule of the *Ranger* type. Protein traces as low as 0.03 micrograms in a sample solution of one milliliter can be detected.

Being developed under a NASA headquarters contract, the instrument detects protein and similar macromolecules by the color change they cause in a carbocyanine dye.

Dyes of this type have previously been used to identify biological materials in microscopic quantities. They are also used extensively in photographic processing.

The color change in the dye, electro-optically detectable as an increase in light absorption at a certain wavelength, is thought to be caused by a change in the aggregation of dye molecules when they contact long chain molecules of the protein type.

Dr. Robert E. Kay, who directs the protein-detection project at PRL, expects that indication of the presence of long chain molecules on Mars will be the minimum information the instrument will yield. Quite possibly, the absorption wavelength will indicate the nature of the molecule detected.

Other proposals for detecting the presence of life on Mars by probe experiments look for a higher level in the evolutionary scale and rely on some form of biological amplification, says Kay. The Gulliver project, for example, aims to detect micro-organisms by growing them in a suitable medium; Multivator aims to detect an enzyme by its ability to break down a phosphorolated fluorescent dye.

• **Direct route**—The protein detector searches for molecules that are characteristic of all living material as we know it. The method does not involve the growth, concentration, or separation of macromolecules (except removal of soil and salts). This directness is one of its chief attractions, says Kay.

Like the other methods, the protein detector experiment is based on the idea that life on Mars would evolve the same way as on Earth, and would be built up from large complex carbon molecules.

The test capsule will pick up about 1 gm. of soil by any one of three methods—a wire brush, a scoop, or a vacuum line. The soil will be treated with about 5 ml. of an appropriate solvent, and the solution processed, mixed with the dye, and examined optically for an absorption band.

Reaction times to produce the complex vary, sometimes extending to 70 minutes.

At least six different absorption bands, believed to correspond to different degrees of aggregation of dye molecules, have been found at PRL with the same carbocyanine dye. Wavelengths of these bands are 450, 510, 535, 555, 575, and 650 millimicrons. The last is called a J-band and corresponds to an agglomeration large enough to be centrifuged.

• **Salts removal**—A J-band can also be formed by the interaction of common inorganic salts with the dye. So removal of salts is an essential first step in the protein detector.

After filtration, the soil solution passes into a dialysis cell, made up of a cellulose tube surrounded by carbowax (a high-molecular-weight polyethylene glycol). This provides a form of ultrafiltration, because the carbowax pulls water and solvent through the cellulose membrane, together with any molecules of less than about 6,000 molecular weight.

With no pressure inside the tube, complete dehydration of the sample takes up to 40 minutes. Solvent is then let into the tube again, and the process repeated.

To examine the effectiveness of the salt extraction, the PRL team has tested what happens if all the material that goes into solution from the soil sample is salt. They find that three dialysis steps are needed to prevent the final solution from producing a detectable J-band.

Three dialysis steps are therefore standard in the instrument's test cycle. Tests on eight Californian soil samples showed that removal of salts and detection of macromolecules was a simple matter with this procedure.

The final solution from the dialysis chamber is then mixed with the dye solution and a comparison is made of the light absorption of the mixture and a pure dye solution, at several wavelengths in turn.

As a further check against the presence of small molecules, these comparisons are made at two different temperatures. Small molecules that cause an absorption band give a solution that decreases sharply in absorbance as temperature increases. Large protein-sized molecules cause either an increase in absorption with rise in temperature, or else the absorption is not affected.

• **Polyphosphates could cause trouble**—There is the possibility that long-chain inorganic molecules in the Martian soil might give a similar color response to carbon molecules. Kay reports that the most troublesome of these appears to be the polyphosphates.

Polyphosphates do not appear in minerals on Earth but react with the carbocyanine dye to give an absorption spectrum similar to DNA. They can be recognized by the fact that the absorption is unaffected by a temperature of 100°C. At this temperature, the dye complex formed by organic molecules is precipitated.

Polyphosphates would invalidate the experiment if they were in sufficient quantity on Mars to use up all the dye.

• **Within state of the art**—Dr. Kay emphasizes that an important feature of the probe is that it needs no major breakthrough to make it work. It is simple and uses established techniques. All parts can withstand sterilization at 140°C for 24 hours.

The main body of the optical null spectrophotometer used to compare the solutions is about 3 in. in diameter and

11 in. long. Light from a small source, collimated by a mirror, passes through one of six narrow-band-pass interference filters carried in a rotating wheel. Selection of the appropriate filter (335, 450, 480, 510, 575, or 650 millimicrons) is made by a stepping motor controlled by a position encoder.

- **How it works**—After filtering, the light meets a beam-splitting mirror that produces four parallel beams of equal intensity. These pass through glass-walled cells to a photocell detector.

One cell functions as a reference cell and contains the standard dye solution. A second functions as the test cell for the mixture of dye and soil solution. The other two are back-up cells to check the results obtained with the first cell.

Resistance heaters control cell temperatures. Quality of the reference dye solution is measured by an electrical conductivity sensor.

The light beams to the cells pass through a mechanical beam chopper that sends pulses of light alternately through the test cell and the reference cell. A mirror system combines the light beams emerging from the cells and focuses the beam into a photocell detector.

When the solutions in the two cells are of equal optical density, the combined light pulses produce a uniform output at the detector. If the absorption of the test cell increases, a pulsed output appears. When a pulsed-output is detected, a shutter in the light path before the reference cell is automatically reduced in aperture until the pulses disappear. The shutter reading obtained from a position encoder then indicates the absorption difference between the solutions.

This information together with the position of the optical filter wheel would be telemetered, indicating the degree of absorbance at a specific wavelength.

For a change of absorbance to be detectable by the instrument, there must be at least a 0.05 difference in the optical density across a 1-cm. path length in the two cells.

- **Physical description**—The complete probe measures about 17 in. long by about 7 in. wide overall. At one end are three soil sample collectors. These are mounted on optical filter housing, which also carries the light source and collimating mirror for the spectrophotometer. In the center of the probe are a nitrogen supply, three dialysis chambers, the variable aperture device, and the test cells. Dye storage and mixing chambers, water reservoirs, and soil-sampler motors are located at the rear end of the probe.

Currently, work at PRL includes improvement to the instrument and study of the possibility of identifying molecules by the absorption bands they produce.

- **Some test results**—In past experiments, distilled water has been used as the solvent, but various other solvents, and the effects of temperature, pH, and osmolarity are being investigated.

Reactions of the carbocyanine dye with 34 proteins, 37 peptides, 4 synthetic polypeptides, 40 amino acids, and 42 carbohydrates, and with DNA, RNA and their derivatives, have been examined at PRL. In trace amounts (less than 0.002%) only proteins, synthetic polypeptides, nucleic acids, and substitute polysaccharides cause changes in the absorption spectrum of the dye.

Mono-, di-, and trisaccharides, purine and pyramidine bases, amino acids, and nucleosides had no effect.

DNA and RNA produce absorption maxima at 575 and 535 millimicrons, suggesting that the particular wavelength of the absorption maximum may indicate the structure of the macromolecule.

For a great many protein-dye complexes, the exact wavelength of the absorption maximum may be characteristic of the protein. ■

astronautics

Project GLOW To Aid ABRES Program

NEW YORK—Flight test activity under Project GLOW, a jointly sponsored Advanced Research Projects Agency (ARPA) and Army research program to gather infrared, ultraviolet, and visible spectra signatures on re-entry vehicles, is expected to begin in August at White Sands Missile Range, N.M.

The program, expected to run for 3-4 years, will be used extensively to evaluate various re-entry bodies associated with the Air Force's *Advanced Ballistic Re-Entry System (ABRES)* probably boosted by the service's new low-cost and lightweight *Athena* launch vehicles (M/R, July 8, p. 18).

Actually, firings from the new Green River, Utah, launch site to the WSMR impact area with the four-stage solid-fuel *Athena* probably will carry identical but sub-scale models of *ABRES* nose cones (M/R, Sept. 2, p. 11). One of the objectives of the *ABRES* flight program, which has already gotten under way at Pacific Missile Range, using *Atlas* ICBM's, has been development of scaling laws which would allow smaller payloads to be used with *Athena*-type vehicles at WSMR.

In addition to *ABRES*, Project GLOW is expected to evaluate many other Army and ARPA re-entry vehicle programs. ARPA, for example, last spring disclosed that it was shifting its *Trailblazer II* target vehicle launches to WSMR (M/R, May 6, p. 16).

The optical re-entry instrumentation system for Project GLOW is described by project sources as the most accurate pedestal-mounted pointing system in existence. A U.S. Army Missile Command contract, thought to be worth more than $1 million, was awarded recently to the Perkin-Elmer Corp., Norwalk, Conn. Under the contract, Perkin-Elmer will supply two identical systems, the first expected to be on site by August. GLOW, which will be a passive system with no associated hardware carried aboard the test vehicle, will operate from two sites to provide different aspects for signature data collection and also to aid data correlation. Information obtained in the program is expected to feed both the development of advanced ground-based detection and discrimination systems and sensors, and improvement of nose cone and decoy re-entry designs.

The optical instrumentation system will have three major functions, according to Perkin-Elmer: acquisition and tracking; radiance information gathering and real-time storage; and data correlation and reduction.

Instrumentation includes radiometers, spectrophotometers, and spectrography. In addition, the system is proposed to include an auto-tracker operating in the IR and visible spectrum, a TV camera and monitor for visual observation of target and booster separation during re-entry, and a boresight camera.

An ROTI camera, also made by the Connecticut firm, will also be included in the system to record re-entry. ■

BREAKTHROUGH

Martin's RACEP, a random access, discrete address system, represents a significant breakthrough in the field of military communications.

It is an advanced combination of radio transmitter-receiver and direct dial telephone, with advantages of both and the drawbacks of neither.

It uses no wires, needs no switchboard.

It can transmit voice, data, facsimile. Handle both individual and conference calls. It is difficult to jam.

It has a command override system that can put a commander in touch with all units immediately.

It is now being field tested by the Air Force.

Available as a vehicular unit or lightweight Manpack.

Martin pioneered this new communication system whic breaks the "voice" into separate pulses which can only reassembled by another RACEP receiver.

Martin is presently embarked on a program to extend rang and flexibility of this system and to give it even broad spectrums of military effectiveness.

Martin is bringing to bear on this project the same system management capability that developed and brought to oper tional readiness such systems as Pershing, Bullpup, Missi Master, BIRDiE and the Titan family.

MARTIN MARTIN MARIETTA

At Martin, Systems Management means the best possible product in the shortest possible time at the lowest possible co

Circle No. 10 on Subscriber Service Card

New Activities

Union Carbide Corp.'s Linde Div., New York, is expanding its production line to include semiconductors and integrated circuits. The company, manufacturer of capacitors and other electronic components, will lease a facility in Palo Alto, Calif. Operation is expected by mid-1964. . . . *Thermo-Physics Corp. has been formed in Cambridge, Mass., to manufacture thermophysical property-measurement equipment. The firm has also established a laboratory to provide measurement services.* . . . Vernistat Div. of Perkin-Elmer Corp., Norwalk, Conn., has changed its name to Electronic Products Div. and has expanded into a new 15,000-sq.-ft. plant in Wilton, Conn. The division produces Vernistat potentiometers, binary and decimal encoders and data reduction equipment. . . . *Meradco, a manufacturing, engineering, research and development firm specializing in liquid, gas and exotic fuel filtration, has been formed in Glendale, Calif.* . . . Philco Corp., Philadelphia, is expanding its research program with the establishment of Philco Research Laboratories. Five laboratories and five support activities are included in the new organization. Advanced research will be conducted in the areas of physics, electromechanics, chemistry, electronics and materials. Dr. Lloyd P. Smith is manager of the laboratories.

Mergers and Acquisitions

Daystrom, Inc., Murray Hill, N.J., electronics manufacturer, has announced plans to acquire Boonshaft & Fuchs, Inc., Hatboro, Pa. B&F designs and produces measurement and test equipment. . . . *Garrett Corp., Los Angeles, has purchased TKM Electric Corp., Rochester, N.Y. TKM, formerly a division of Dynamic Electronics, Inc., produces alternators and generators.*

Comsat Stock To Cost $20/Share

Communications Satellite Corp., Washington, D.C., is expected to offer about $200 million worth of stock sometime in April. Managing underwriters' suggested price for the 10 to 11 million shares is $20 per share. Comsat is now preparing to register the stock with the Securities and Exchange Commission.

In the Courts

Dynamic Corp. of America and its division, Reeves Instrument Co., Garden City, N.Y., have filed a patent-infringement suit against Beckman Instruments, Inc., Fullerton, Calif., in a U.S. District Court. DCA and Reeves have asked for an injunction plus damages and costs for Beckman's use of a Reeves-patented "method and apparatus" for checking analog computers.

Company Representatives

Engineering Supply Co., Canton, Mass., has been named distributor for Texas Instruments, Inc.'s line of semiconductors, resistors and capacitors. ESC will cover the greater Boston area. . . . *Cliver Sales Engineering Co., Westfield, N.J., has been appointed sales representative for Aero-Space Avionics, Inc., Farmingdale, N.Y. Cliver will handle AA's line of special support equipment instruments and subsystems in New Jersey, Pennsylvania and Westchester County, N.Y.* . . . Applied Engineering Products Co., Stamford, Conn., has named Reagan Electronics, Albany, N.Y., sales representative for upper New York state. Reagan will handle the AEP line of subminiature and microminiature RF coaxial connectors. . . . *Advanced Development Laboratories, Inc., Nashua, N.H., has named three new representatives for its line of radar systems and subsystems. The Jay Co., Timonium, Md., and Arlington, Va., will represent ADL in Delaware, Maryland, Virginia and Washington, D.C. E. G. Miller Co., Inc., Henderson, Tex., and Albuquerque, N.M., will cover Texas, Oklahoma, New Mexico and Arizona. Gordon Fixman Engineering Co., St. Louis, Mo., and Wichita, Kan., will handle Kansas, Missouri and southern Illinois.* . . . Atohm Electronics, Sun Valley, Calif., has named Newark Electronics national distributor for its line of trimmer potentiometers.

New Facilities

Tektronix, Inc., Beaverton, Ore., has completed construction of a 35,000-sq.-ft. electrochemical building. The facility is part of the firm's multi-million dollar building program that will group functionally related operations. In design or planning stages are a 220,000-sq.-ft. technical center and a maintenance building. . . . *Marquardt Corp., Van Nuys, Calif., is constructing a facility for testing advanced propulsion devices. The 640-acre test site is located on Magic Mountain, 30 mi. north of the main plant.* . . . Computer Associates, Inc., formerly of Woburn, Mass., has moved to a new plant in Wakefield, Mass. The firm specializes in digital computer programming fields. . . . *B. F. Goodrich Co. has leased 32,000 sq. ft. of the Chemical Bank New York Trust Building and will move its Manhattan-based operation to that location May 1.* . . . Lindberg Steel Treating Co., Melrose Park, Ill., has completed a $150,000 expansion of its corporate offices. The company maintains missile and rocket facilities at the Illinois plant. . . . *Corning Glass Works has announced plans to double its research and development facilities at the Corning, N.Y., plant. The company will construct two new buildings, a total expansion of 295,000 sq. ft.*

Aerojet-General Corp. has begun construction of a $2.4-million corporate headquarters building at El Monte, Calif. . . . *The Hamilton Watch Co., Lancaster, Pa., has placed in operation a new materials testing laboratory equipped with advanced apparatus for measuring the soft magnetic properties of alloys. The laboratory will enable Hamilton to provide special tests related to specific customer requirements in addition to standard ASTM magnetics tests for soft magnetic materials.*

SPACE ELECTRONICS

British Firm Using Low-Cost Method To Package Miniature Components

by Frank G. McGuire

LONDON—A low-cost, high-reliability method for dense packaging of miniature electronic components without necessity for large-volume production has been applied to logic circuits for the first time by Standard Telephones and Cables Ltd.

The concept, called Ministac, was developed at STC's Standard Telecommunication Laboratories and is now being used on a production basis, with many applications foreseen in the missile/space field. One of the principal benefits of the approach is that it permits small production runs of subassemblies without prohibitively high cost levels per item.

H. T. Prior of STC told MISSILES AND ROCKETS that electronic packages nearly solid with components could be fabricated by an all-mechanical process requiring no elaborate jigs. Production runs can range from 10 to well over 10,000 with the simple, reliable process.

"Although research along these lines is essentially the same in Europe as in the United States," he said, "it must be on a smaller scale because of financial limitations as well as the fewer number of complete systems required. Therefore, we've turned to a method of economically producing the relatively small number of systems we need."

- **Design**—STC has dealt with this limitation by using a stacking method somewhat similar to the "cord wood" technique pioneered in the *Polaris* program, although modified to a certain extent. Fabrication methods are essentially the same, but are geared to compatibility with the theme of low costs despite low volumes.

Paper tape controls punch connections, or wiring, from solid metal, and components are then stacked within a rectangular framework of this connection network. In addition to the low-cost, low-volume requirements for development of the Ministac method, STC engineers aimed at maximum versatility. Thus, even though of great use for miniaturized electronics, there are also applications to systems using non-miniaturized components such as inductors and variable resistors and capacitors.

- **Fabrication**—Each Ministac is a module with plug-in connections and has two side plates, which carry terminals for mounting of components. These two plates and their internal terminals are supported by end plates carrying external, or module terminals. Alternatively to the plug-in type connections, the module can be made so that the wires for each component can be used as leadout terminals.

Special Section

Each month, the first issue of MISSILES AND ROCKETS contains a special section devoted to the latest developments in the field of space electronics, including new products.

The section begins on this page with an article by European Correspondent Frank McGuire about a British-developed method for packaging miniature components.

Other articles in the section:

- Page 35—Electronics Editor Rex Pay discusses flight-control circuits that have allowed significant weight reduction in the Improved Minuteman's third stage.
- Page 36—M/R details a six-foot-high omnidirectional antenna that approaches the efficiency of 120-ft. models.
- Page 37—Electronics Editor Michael Getler presents an industry consensus on improving radiation-resistant semiconductors.

The internal terminals, punched from semi-rigid metal strips, are on a 0.1-in. pitch and slotted to accommodate component leadout wires. STC says a central feature of the design is that these terminals are integral with the module's wiring, which is attached to the side plates. Stock material used for internal terminals and connections is nickel-silver strips of 0.010-in. thickness punched with a standard pattern.

The border of the strip is perforated with holes similar to a roll of 35-mm photographic film to permit the strip to be fed into automatic punching equipment. This perforated border is kept on the strip until module assembly, when it is cut off. Until then, it serves to keep the interconnection pattern intact and makes handling easier. Upon cutting off the border, the slotted terminal tags for receiving component leadout wires are automatically produced.

Until the border is cut off, the strip is run through equipment that removes certain portions of the standard pattern, leaving behind the desired network of terminals and interconnections This grid is planned by STC engineers on the basis of standard schematic diagrams, which are re-drawn for the purpose of determining optimum design

- **Assembly**—Two differently-designed grids are attached to the surfaces of an insulating material to form one side plate. In simple circuits, th company points out, only one such grid may be needed. The insulating plate is surfaced with stubby projections, or knobs, which match the circular holes remaining in the nickel-silver strip.

The strip is placed over the insulating material, pressed down so the knobs pop into the holes in the strip, then heat and pressure are applied to soften the insulating material and expand it somewhat like a rivet, thus securing the two materials together. At this point, the border is trimmed off and what remains is a sideplate complete with wiring terminals, interconnections, insulation and component-connection slotted tags.

End plates are made in somewhat the same fashion. The number of terminals that can be incorporated into one end plate depends on terminal spacing and the internal width of the module. The maximum useful number of terminals on each end plate is four, with two connecting each side plate.

"Using 0.2-in. spacing, for example, with solderless wrapped joints, three terminals can be provided if the internal width is 0.5 in., and four terminals can be provided if the width is at least 0.7 in.," Mr. Prior said.

End plates can also be used anywhere within the module to provide extra external terminals if desired. Side plates and end plates are secured together by engaging the lugs on the end plates with the slotted terminals on the side plates and soldering. As an alternative, the slotted terminal can be clenched onto the lug.

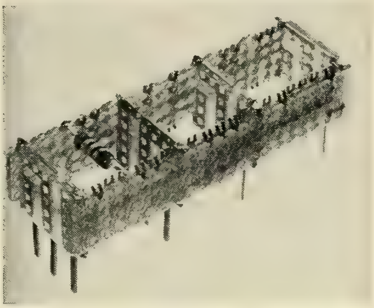
Components with wire ends can be mounted directly by soldering to the tags, and components requiring more support than afforded by their leadout wires can be mounted on sub-plates. Inductors, potentiometers and other components used in non-digital work can also be easily accommodated.

• **Dimensions**—Principal dimensions involved in a Ministac module can be varied considerably. Normal maximum length without using joining moldings is about 6 in., variable in steps of 0.1 in. Internal width is variable in steps of 0.1 in. up to about 2 in. and external width is essentially governed by the thickness of the side plates, each of which has a maximum thickness of 0.1 in. Thus, external width is equal to internal width plus 0.2 in. Height of the module is fixed at 0.5 in. over the terminal tags, although components may be allowed to extend beyond this dimension if sufficiently protected.

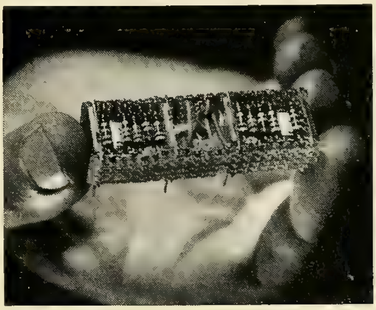
• **Internal design**—Up to six interconnection tracks running the length of each side plate can be handled in the Ministac module. The tracks are divided into sets of three, with one set for each surface of the plate. The planar form of each set of three, however, places certain limitations on the ways in which the main interconnecting tracks can be brought out to the component-attachmen terminals.

STC feels that these limitations are unimportant for circuits like triggers, normal and IF amplifiers, oscillators, etc., and in practice the company has had no trouble in designing circuits. Occasionally an extra wire is needed to provide a necessary connection.

The firm has adopted a systematic design approach that provides a control tape for the automatic punch machine.



ABOVE: Ministac module basic stack at beginning of component assembly. BELOW: Completed Ministac module developed by Standard Telecommunication Laboratories.



• **Design approach**—Using a normal schematic as a starting point, STC engineers turn out an interconnection diagram in which the components are arranged in a row approximately as they appear in the original schematic. However, the objective is to make one set of interconnections between components (the Y-board) as simple as possible. The set of connections for the X-board will be located on one side plate and the set for the Y-board will be located on the opposite side plate.

Next, a packing diagram and a detailed interconnection diagram are produced. At this stage, the objective is to maximize the packing efficiency and still use the X-board interconnection grid to best advantage. Thus, any interconnections crossing a vertical line must be limited to not more than three horizontal tracks on each of the two layers of punched wiring.

Final step is the design of the Y-board interconnections, which, at the outset were made quite simple. Consequently, when the designers tackle the job of arranging components for optimum packing and use of the X-board grid, it leaves the Y-board relatively simple. The Y-board is nearly always considerably less complicated than the X-board and well within the scope of the interconnection capacity available.

STC's procedure, then, enables design attention to be concentrated on one step at a time. Time required for the planning process will depend upon the designer's experience and the extent to which dense packing is vital in the particular case. An approximate time given by STC for design of a trigger circuit is four hours.

• **Salient features**—Aside from the basic advantage of low-volume production without excessive costs, STC feels the Ministac approach makes it possible to embody any normal circuit without difficulty into the two-wiring-grid module, and simpler circuits into only one grid. The terminal tags and the interconnections are integral so there are no connections to be made except from the components to the side plates and end plates.

The only control information necessary consists of a punched paper tape for the automatic nickel-silver strip-punching equipment. The only operation required to completely change over from one module's side plates to that for another module is to change the tape on the strip-punching machines.

Either soldered connections (as presently used) or welded connections can be applied to module fabrication.

Component assembly can be arranged either by hand or by automatic equipment, and a solid tag is provided on the module for the attachment. Any component can be removed and replaced without danger of damage to adjoining components or connections. Access to adjustable components is possible through either of the two open faces of the module.

STC points out that the internal spacing of tags at 0.1 in. and the flexibility available in dimensions of the module give a considerable variety of applications.

• **Fabrication equipment**—Design of the manufacturing machinery was carried out concurrently with design of the module concept itself, Mr. Prior said. The control information for the wiring grids design is carried by a loop of paper tape pre-punched. The loop is read by a tape reader, which actuates a set of air cylinders operating punches.

The bulk-produced stock material of nickel-silver strip is fed into these punches and emerges as a continuously running set of four grids for a particular module design. ■

ENGINEERS & SCIENTISTS

ALL CHIEFS, NO INDIANS!

With tongue in cheek, this phrase might be applied to the scientists and engineers of Pan Am's Guided Missiles Range Division. Under the direction of the U.S. Air Force Missile Test Center, GMRD has, since 1953, been responsible for conceptual planning, specifications, and operation of the range instrumentation systems developed by industry for the Atlantic Missile Range. The decisions made by Pan Am's technical staff are vital... directly affecting the success of each missile, space vehicle, and scientific probe launch operation at Cape Kennedy.

RANGE PLANNING analyzes projected program requirements up to 15 years ahead, predicts range support capability required and develops the advanced instrumentation system concepts.

SYSTEMS ENGINEERING utilizes these range plans to develop detailed specifications for all range instrumentation, data, and support systems. They then evaluate bids from industry to insure that capable industry sources will furnish such systems. This is only the beginning of their task – they follow and monitor the development of this equipment through installation and checkout.

RANGE OPERATIONS plans and evaluates range support for all launches, coordinates all range support activities, provides data and command/destruct for range safety, and manages the operation of down-range stations.

Individually and as team members, the men in these groups have become authorities in range technology. To add to the capability of the range, the following typical assignments are under way in Range Planning, Systems Engineering, and Range Operations:

CW and Pulse Radar: modify and improve sensitivity of Mistram, Glotrac, AN/FPQ-6, and AN/TPQ-18; develop velocity measuring system with an accuracy of 0.1 fps.

Telemetry: increase the operating range of antennas to cover frequencies up to 2300 mc; design a system which, upon command, will select the most important data from each station.

Optics: devise and install an orientation system for both CZR and cinetheodolites; improve ballistic cameras with respect to random errors, shutter speed, exposure time and time correlation.

Infrared: develop high resolution spectrometer for launch and re-entry coverage; implement a complete infrared measurement system for mid-range coverage.

Underwater Sound: introduce a nuclear battery power supply into the ship-tended acoustic relay (Star) and extend the range of this system.

Data Processing: add automated methods to enable more efficient handling of larger volumes of data with minimum degradation; convert processing of weather information to near realtime.

Meteorology: improve cloud height and growth indication instrumentation; develop a system to measure atmospheric electrical potential and cloud movement.

Instrumentation & Vehicle Control: automate the entire tracking network through a Range Instrumentation Control System; add space diversity to the Cape Kennedy command control system by adding a van-mounted 10 KW fast-reaction command control system.

Correlation: reduce time correlation uncertainty across the range to less than 100 microseconds; standardize the timing signal format on the AMR.

Radiometry: schedule and control all electromagnetic radiation within the missile test area with a Spectrum Surveillance System; automate, where possible, instrumentation for interference control, spectrum signature collection and quality analysis.

Data Handling: design equipment to permit very high density realtime data transmission over RF lines or submarine cable; increase the digital data equipment available at off-cable sites to provide more efficient on-site computer programming.

Range Safety: increase the electronic monitoring of launch hazard areas and of missile and spacecraft performance; install a second Range Acquisition Data Distribution & Control system to permit handling of dual missions; develop instruments to measure blast parameters and fireballs resulting from exploding missiles.

Ship and Aircraft Instrumentation: improve the instrumentation to meet more stringent telemetry, navigation, tracking, communications, and data handling requirements; phase into operation new and/or modified tracking ships and aircraft.

Engineers and scientists with applicable experience are invited to write in confidence to Manager – Professional Employment, Dept. 56C-1.

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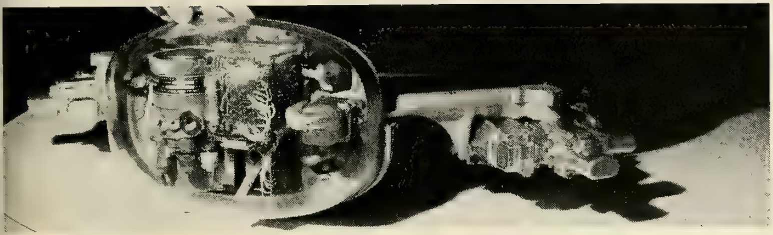
Circuit Weight Slashed In Advanced Minuteman



by Rex Pay

Los Angeles—Weight and volume reductions of 10 to one in *Improved Minuteman* flight-control circuits have enabled their relocation from first- and second-stage positions to the third stage, without a range-payload penalty.

Most of the flight-control circuits are now located in the guidance and control compartment, behind the payload. They can be replaced without removing the missile from the silo, reducing field maintenance cost considerably.

Main contractor for the *Minuteman* guidance and control system is Autonetics division of North American Aviation, which displayed components of the system at the 1964 National Winter Convention on Military Electronics.

- **Second stage refinements**—The *Improved Minuteman* (WS-133B) provides increased range and accuracy compared to the WS-133A *Minuteman*, chiefly through use of a new second-stage motor and a navigational computer of increased capacity (M/R Oct. 7, p. 43).

Instead of gimbaled nozzles, the second-stage motor uses secondary injection thrust vectoring, and a new flight-control system has been designed for it.

Freon is injected downstream of the throat of the single second-stage nozzle. The resulting shock wave, pressure field, and momentum tranfer deflect the main thrust vector.

Freon is injected at four locations spaced 90° apart around the nozzle by means of two hydraulically-actuated valve units. Each valve is capable of a maximum flow of about 60 lbs. per sec. The freon is contained in a circumferential tank around the main nozzle.

Because enough freon is carried for the most demanding mission, a range penalty is incurred if some is not dumped on a smooth flight.

During flight, the amount used is monitored by analog pick-offs that indicate valve position. All four analog outputs are summed and integrated to measure total freon used. After the amount of freon that can be dumped has been computed, it is jettisoned by fully opening all four nozzle systems. This also gives additional thrust.

- **Controlling roll**—Roll control on the first and third stages is carried out by differential movement of the four gimbaled nozzles, as in WS-133A. On the second stage of the *Improved Minuteman,* however, roll is controlled by diametrically opposed hot gas nozzles. The missile is not allowed to roll, being maintained with one side always pointing down.

Roll correction is varied by means of flappers in the hot gas nozzles. The flappers are centered for no correction.

Rate sensing in roll is carried out by the main guidance platform in the third stage. Rate sensing in pitch and yaw on the second stage is carried out by a force re-balance angular accelerometer.

Electronic circuits located in the second stage include secondary power supplies, a de-modulator and a roll switch. Discrete components are used throughout these electronic circuits, primarily because of the low volume of components and the absence of common functions. Main power supply on the vehicle is 28 volts dc from batteries in the first and third stage. AC supplies from these are produced by solid-state converters.

There are two solid-propellant hot gas generators in the second stage. One provides gas to pressurize the freon tank; the second supplies the hot gas for roll control.

- **Third stage makeup**—Most of the electronics for the flight-control system are located in the amplifier assembly in the guidance and control section between the third-stage motor and the payload. This assembly contains several servo amplifiers and also semiconductor power switches that provide 10-amp signals to activate ordnance functions such as staging, engine ignition, and thrust termination.

Also included are power supplies, plus circuits to select the proper group of servo amplifiers and to decode the ordnance commands. These functions are performed by about 260 integrated circuits.

The torque supplied by the flight-control system to the first stage nozzles is 26,000 inch-pounds. Torque on the third stage nozzles is about 8,000-9,000 inch-pounds. This is because the stage is not only smaller but is also operated outside the atmosphere so that the nozzles do not have to combat aerodynamic forces.

The hydraulic pressures used in the first, second, and third stages are 3,000 psi, 500 psi, and 1,500 psi, respectively, with the injection system requiring much lower pressure than the gimbaled nozzles.

The two electro-hydraulic control assemblies for the first and third stages are located in the center of the four nozzles and are covered with a white silicone rubber ablative material.

- **Combating heat**—Exhaust gases in the second stage are isolated from the injector controls by the main nozzle walls but are subject to radiated heat. For this reason exposed hydraulic components are made highly reflective, and the hydraulic power supply and electronic units are contained within a gold plated housing.

On delivery, the reflectivity of these units in the infrared range is about 90%, which allows a margin of degradation with time in the field. The gold-plated cover for the control system also serves as a pressure vessel to withstand the shock pressure of second-stage ignition.

A feature of the hydraulic system is that there are no pipes or connectors. All fluid passageways are integral with the casing and mounting brackets of the various components. ■

Firm Makes Low-Profile High-Efficiency Antennas

NEWBURY PARK, CALIF.—A six-ft.-high omnidirectional antenna with an efficiency approaching that of a 120-ft.-high tower antenna has been installed on the Pacific Missile Range tracking ship USS Wheeling, currently docked in New Orleans.

This 35-ft.-dia. prototype unit operates over a 2 to 30-mc frequency band and was built by Northrop Ventura division under a $114,000 contract with the Navy.

The company is now thinking of proposing antennas of this type—the Directly Driven Resonant Radiator (DDRR)—for about 35 tracking ships and 40 ground tracking stations around the world.

Advantages of low antenna height are reduced vulnerability to damage from winds, lightning, or low-flying instrument-recovery aircraft, and reduced maintenance costs. Its low profile also makes it suitable for hardened installations.

Penalties incurred in comparison with a quarter-wave vertical are increased use of ground area and about 1.5 db loss in signal strength.

Northrop Ventura has completed Phase I of an Army contract for a transportable 70 to 130-kc DDRR for jamming navigation and position-fixing systems. Negotiations are under way for Phase II of this contract and for another concerned with development of a DDRR for higher frequencies, probably for fuse jamming.

- **First used in target drone**—The DDRR evolved from a circular antenna used in a target drone. In its basic form, it consists of a horizontal ring broken at one point, with the two ends connected to an efficient ground plane. One connection is directly through a short vertical post, the second is through a tuning capacitor.

In this configuration, the antenna is suitable for narrow-band operation (0.5% of operating frequency) between 70 kc and 300 mc. The circumference of the ring is less than a quarter of the operating wavelength and it is located about 0.016 of the wavelength above the ground plane.

Although the basic type of DDRR can be tuned over a limited frequency range by adjustment of the variable capacitor, the radiated field strength decreases as the tuned frequency rises.

This problem is overcome in the double-post DDRR. In this, a straight conductor is substituted for the tuning capacitor, which is reconnected between the ring and the ground plane at a point about half-way between the two end posts. This version of the DDRR has nearly four times the radiation resistance of the single-post model and is tunable over a 1.7 to 1 bandwidth without noticeable loss of signal strength.

- **Wheeling configuration**—The antenna installed on the USS Wheeling consists of five concentric ring systems of the double-post type. Frequency coverage is divided between the five rings as follows: 2.0 to 3.3 mc, 3.3 to 5.75 mc, 5.75 to 10.0 mc, 10.0 to 17.2 mc, 17.2 to 30.2 mc.

Transmission tests from Newbury Park, California, to Hawaii showed that the prototype PMR antenna performed as well as a nearby quarter-wave vertical. Signals from the two antennas arrived at Hawaii with strengths that fluctuated within ±1 db of each other.

The circular configuration is not essential and other shapes can be used to suit available space. The 35-ft.-diameter PMR ship antenna could have been reduced in size by spiralling, but adequate space was available on top the ship's helicopter hanger.

For Atlantic Missile Range ships, Northrop Ventura has proposed a 16-ft. square configuration.

Power feed to the DDRR is by means of a coaxial transmission line directly connected to one vertical post. The post serves as an auto transformer, the height of the tapping point being selected to give correct impedance match.

Main radiating parts of the DDRR are the vertical post and the vertical conductor containing the capacitor.

The antenna presents the feedline with the equivalent of a high-Q parallel tuned circuit. High Q is not the result of low radiated energy, but is only an apparent Q caused by the fast-changing input impedance of the top-loading. The input impedance changes much faster with frequency than the reactance of a lumped capacitor.

- **Use in Gemini proposed**—The high apparent Q gives the DDRR its frequency-selective characteristics, which can be of value in reducing adjacent-channel interference and improving signal to noise ratio.

Low profile and the weight saving brought by the absence of a matching network make the DDRR suitable for use in space vehicles. Currently, Northrop Ventura is proposing that the 2-ft. stub antenna for *Gemini* communications should be replaced by a DDRR.

Northrop Ventura, which has the contract for the *Gemini* parachute system, says that there is the possibility that a parachute line might foul the stub antenna. This might either damage the line or snap off the stub, breaking the communication link.

The ring antenna that would replace the stub (240 mc) would be about 1.5 in. high and would be covered by a low radome. Studies are in hand to see where the radome can be located to reduce effects of re-entry heating.

- **Roll up antenna for ECM**—Recently Northrop Ventura has developed a prototype transportable DDRR for jamming operations at frequencies between 70 and 130 kc. It is a single-post type, designed to replace a 120-ft. top-loaded umbrella. (A quarter-wave antenna at this frequency would be about 10,000 ft. high.)

The antenna, which is in the shape of a square spiral of Litz wire woven into a grid of nylon webbing, can be rolled up like a carpet. Overall size of the nylon grid is 35 x 35 ft. The ground plane is a 100 x 100-ft. screen of aluminum mesh. The whole system has been designed for transport on an M36C Army truck with a 1.5-ton trailer.

When raised by pulleys to the top of 35-ft. vertical posts, the antenna has an efficiency of 1.5%, which is greater than that of the top-loaded umbrella.

The ability to vary the frequency of the DDRR antenna by simple adjustment of one tuning capacitor is particularly useful in electronic countermeasures applications. ■

Design Seen as Interim Solution to Circuit Irradiation

by Michael Getler

PHILADELPHIA—Next round of improvements in radiation-resistant semiconductor circuits, according to panelists discussing the subject at the International Solid-State Circuits Conference held here last week, is more likely to come from increased attention to circuit design and improved test data correlation than through continuing refinements in material technology.

Though some engineers still see another order-of-magnitude of "hardness" improvement possible within the transistor technology, it is felt by many that "further progress is now getting painful" and that advances of that degree will take another 2-5 years, generally paralleling progress of active elements into the 10-50 gc range.

In the interim, most experts agree that considerable progress can be made by clever circuit design using available componentry in optimum arrangement.

Improved hardness is generally achieved at the expense of switching capability for digital circuits, increased numbers of components, higher power, and increased cost. The specific design, in turn, is further influenced by the predicted radiation environment (both the spectrum, length, and type of exposure) and the material structure and temperature sensitivity of the componentry.

- **Radiation resistance complex**—While many engineers seek more definitive guidelines and values for radiation-resistant circuit design, experts point out that these very complex variables and possible trade-offs make it difficult to approach specific circuit design with anything but broad generalizations until virtually all mission and operating needs and restraints are detailed.

What is needed, many users feel, is increased radiation environment testing at the manufacturer's level, providing correlated radiation level-electrical response data similar to that now provided for other environments. Considerable uncertainty continues to surround the measurement and value of the "K" factor, the constant that basically indicates how fast the lifetime of a device is being degraded.

While K is generally known to within a factor of three, it is not known with much more accuracy with respect to a single device or a class of transistors. Data in the latter case is even more difficult to collect since slight differences in processess used by various manufacturers of the same class of device can alter the hardness while not affecting the general operating specifications.

- **Radiation effects explained**—There are two basic types of transient radiation effects on semiconductor devices. A high-intensity radiation pulse causes ionization that will usually decay in a few microseconds to a few milliseconds, according to D. Landis of the Sanford University Electronics Lab. Circuit design for this transient, he pointed out in a presentation here, should provide for recovery before requiring that it operate.

The other transient effect, which may occur at low radiation intensity, is the result of the collection of ions on surface regions with high-electric-field intensity. This effect, says Landis, can be minimized by using silicon planar devices with passivated surfaces, and by avoiding prolonged application of reversed bias to a junction operating in a radiation field.

While there is general agreement that stray radiation pulses, even though of significant strength, may not be permanently damaging if they are of short duration, experts at the meeting pointed out that it is vital for digital circuitry to be able to recognize these spurious signals in order to achieve the proper smoothing.

Though short pulses may be overcome, there are upper limits above which circuits will not recover, primarily because of severe temperature changes in the silicon or other base material. These thermal effects are now of principal concern in establishing radiation dosage limitations.

The time in which a circuit can recover is also closely studied. For example, panelists here report major interest in developing improved telemetry circuits capable of functioning in the area of a weapons burst either during the burst or a few milliseconds after.

- **Hesitance on thin film**—When questioned about the prospects for thin-film active devices, panelists—from the Sandia Corp., IBM, and General Atomics—were reluctant to claim major gains for this approach until experimental data were available. One scientist pointed out that while induced currents may be less with thin films, what is really important to radiation environment operation is the ratio of the induced current level to the signal level.

The main permanent damage effects of radiation on junction devices are decreased gain, and increased leakage currents, diode voltages, and saturation voltages.

In a rundown of general semiconductor suseptibilities presented here, Landis reported that tunnel diodes, zener diodes, and high-speed switching diodes are relatively radiation resistant. Silicon-controlled rectifiers, unijunction transistors, and low-frequency thick-base transistors are easily damaged by radiation and should be used with caution.

High frequency transistors and field-effect transistors are moderately sensitive to radiation, he said, and are the most useful active elements for radiation-resistant semiconductor circuits.

Field-effect devices, Landis says, have a higher damage threshold than ordinary transistors, but a very-high-frequency transistor may still have usable gain left at radiation levels that destroy the usefulness of field-effect transistors. Germanium devices are perhaps slightly less sensitive to radiation than equivalent silicon devices, but the difference is small for components.

(continued on page 38)

● **New design rule needed**—"Design for low beta," says Landis, "seems to be the standard rule for radiation-resistant circuits. A better rule is to determine what happens to the components in radiation, and design the circuits to work when it happens."

Regarding care in choosing circuit elements, Landis reports that passive components are generally more stable in radiation environments than active components; thus a radiation-resistant circuit should have minimal dependence on active device parameters.

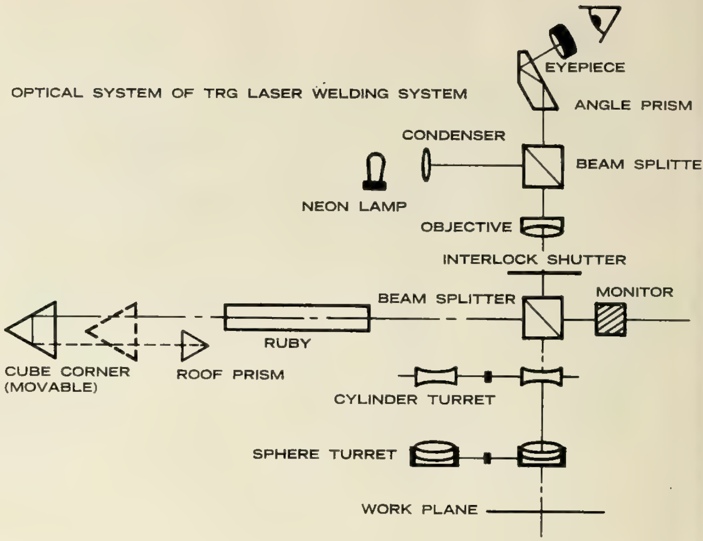
For example, Landis says that diodes are less sensitive to radiation than transistors and therefore diode logic should be used unless the extra gain of transistor logic is needed. An oscillator should be designed to give negligible loading on its tuned circuits or crystal, even after irradiation. Amplifiers should have their characteristics controlled by feedback through passive components, and should have sufficient open-loop gain after irradiation so that their characteristics do not change.

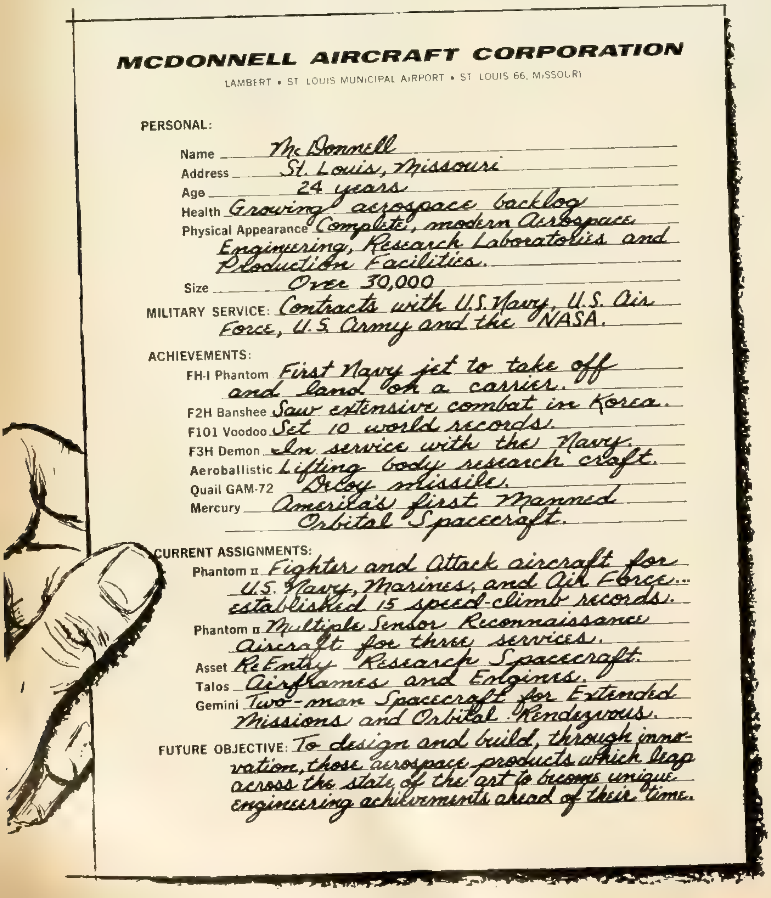
Switching circuits, he says, can generally be made less sensitive to radiation than analog circuits. Since many basically analog or anolog-to-digital system functions can be realized with mostly digital circuitry, Landis says, this approach should be considered. ■

New Product of the Week:

Laser Welding Syste

OPTICAL SYSTEM OF TRG LASER WELDING SYSTEM

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A laser beam welding system for missile/space materials has been developed and manufactured by TRG, Inc.

The system consists of a power supply, pulse-forming network, ruby laser head with associated optics, cooling system, positioning table and control console. Power input is 220v, 60 cps, 3 phase. Maximum output voltage is 3,000v. Energy delivered to the flash lamps can be adjusted up to 30,000 joules.

The system can be used in single-pulse or multiple-pulse modes of operation at rates from one pulse per 12 seconds to one pulse per second, depending on material, thickness and type of weld. The laser beam can be varied from 0.060 to 0.640 in. in length. There are 10 capacitors of 580 μf each per capacitor bank.

Circle No. 151 on Subscriber Service Card

Day/Night Camera

A 70-mm. reconnaissance camera with a 24-hr. photographic capability is being marketed by Itek Corp.

The device uses standard flash cartridges or can be adapted for use with stroboscopic light. Lens is 52 mm., f/3.5 to f/22 Kaligar. Lens coverage is 58.6 degrees. In-flight power requirement is 28v dc, 75 watts. Shutter speeds are bulb and 1/60, 1/125, 1/250 and 1/500 sec.

The sensor weighs 6 lbs. and measures 4 x 8.38 x 6.5 in. Resolution is lens-film limited providing an AWAR of over 53 lines/mm. on Panatomic-X film and 18 lines/mm. on Royal-X Pan film.

Circle No. 152 on Subscriber Service Card

X-Y Recorder

Houston Instrument Corp. is marketing the Model HR-98T X-Y recorder, measuring 11 x 17 in.

The model features 1 mv/in. sensitivity, switch selectability to 10 v/in. in five steps with vernier control between ranges. Input impedance is 100 K; accuracy is 0.25%; X-axis time sweep is from 0.05 to 2 in./sec. in six steps.

Circle No. 153 on Subscriber Service Card

Coaxial Transfer Switch

E&M Laboratories has developed the Model VC13SC coaxial transfer switch for missile and spacecraft applications.

Specifications include a 0 to 6.0-gc frequency range and 40-db minimum crosstalk. Insertion loss is 0.3 db maximum; VSWR is 1.25 maximum. The unit can withstand shock of 50 g's minimum in three axes. Operating temperature range is —55° to 100°C.

Hermetic sealing and remote position indicator circuits are available on request.

Circle No. 154 on Subscriber Service Card

Phase Shift Circulator

A differential phase shift circulator that can be operated at 25 kw CW with a 6:1 load mismatch is being marketed by Raytheon Co.'s Special Microwave Devices Operation.

The model CXH-25 operates at 8.35 gc with isolation of at least 20 db and insertion losses no greater than 0.3 db. VSWR is 1.15. The device is designed for pressurized cooling with water circulation of 1.5 gal. per minute at 150 psi.

Circle No. 155 on Subscriber Service Card

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missiles and rockets

DOD Military System

A Report on the DDR&E

DDR&E, the Directorate of Defense Research and Engineering, is one of the most important offices in the Department of Defense. It has a complement of 145 men, supervising some 30,000 others and directly affecting over 125,000 industry personnel. DDR&E annually contracts for $7 billion dollars in space and military systems research, development, test and engineering services from its suppliers.

The March 30 issue of MISSILES AND ROCKETS will present an in-depth report on DDR&E covering:

DDR&E Operation ▪ Relationships with Industry and the Services ▪ Current & Advanced Programs ▪ In-House R&D Capabilities ▪ Future Expenditures ▪ Key Personnel

Issue Date: March 30, 196

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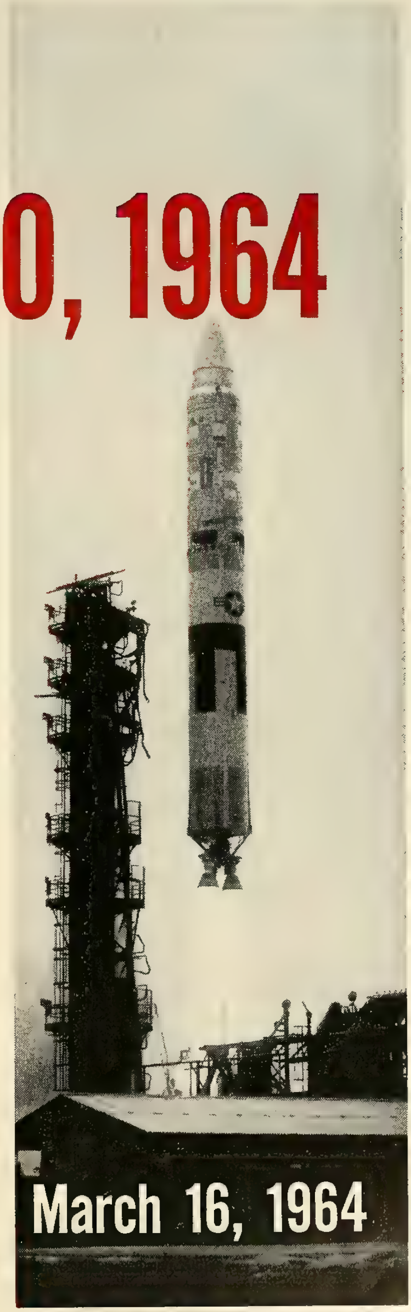

The DOD Military Systems

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In MISSILES AND ROCKETS — 275 page advertising gain in 1963 over 1962; 3700 new paid subscribers gained during 1963; total paid circulation of over 45,000.

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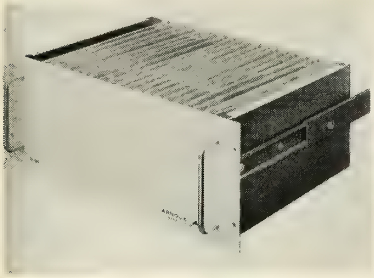
Telemetry/Control System

Arnoux Corp. is marketing the model TAC-1000 self-adaptive telemetry and control system, designed so only those parameters of concern to operating personnel need to be transmitted. Wide-band communication links needed to transmit redundant data via conventional PCM telemetry techniques are not required.



The device features from 10 to 1,000 input channels; go/no-go data; variable word length; a self-adaptive format and solid-state design.

Circle No. 156 on Subscriber Service Card

Antenna Multicoupler

Aerospace Research, Inc., is marketing a line of Type PMC transmitter/antenna multicouplers, available with combinations of center frequencies, bandwidths and channel spacings.

The six-channel model in the 800 to 820-mc range with channel spacings of 4 mc has 3-db bandwidths of 1.3 mc and isolation of greater than 20 db between channels. Insertion loss is less than 2 db; VSWR exceeds 1.2:1. The unit can handle more than 100w per channel up to 85°C.

Circle No. 157 on Subscriber Service Card

Noise Analyzer

Quan-Tech Laboratories, Inc., is marketing the Model 312 analyzer, which provides a three-point spectrum analysis of the noise characteristics.

The device makes measurements at 100 cps, 1 kc and 10 kc simultaneously. Respective measurement thresholds are approximately 1.5, 1.1 and 0.7 pa/root cycle. Drain voltage range is 0.1 to 30v; drain current range is 0.05 to 30 ma. Gate bias is continuously variable from 1v forward to 15v reverse.

Circle No. 158 on Subscriber Service Card

Measuring Counter

Computer Measurements Co. has developed the Model 738B solid-state frequency measuring counter.

The device measures all tone and RF frequencies from 10 cps to 100 mc directly with accuracies up to 0.000005%. When used with a plug-in heterodyne converter, it measures frequencies to 500 mc. Readout is seven digits in kilocycles. Sensitivity is 0.1 RMS (2v maximum). Stability is 5 parts in 10^8 short term and 5 parts in 10^7/week long term.

Circle No. 159 on Subscriber Service Card

Isolator

Raytheon Co.'s Special Microwave Devices Operation has developed a 1,250 to 1,350-mc isolator, the Model ILH37.

The water-cooled device, which is 14 in. high, handles 2.5 Mw peak power and 5 kw average power into a load mismatch of 1.5 to 1. Insertion loss is less than 0.65 db with 10-db minimum attenuation. Maximum VSWR is 1.20:1.

Circle No. 160 on Subscriber Service Card

Antenna Positioner

Andrew Corp. is marketing an elevation-over-azimuth positioner for microwave antennas, designed for a tactical communications system.

The type 30131 will withstand 125-mph winds with a 6-ft. parabola in place and is operational with ±1° accuracy in 30-mph winds. Elevation and azimuth functions are remotely operated. The unit is fitted with a reverse locking clutch and a locking screw mechanism to prevent torque feed-back from the antenna.

Circle No. 161 on Subscriber Service Card

Encapsulated 'Stick'

International Rectifier Corp., is marketing a line of encapsulated "sticks" capable of handling peak reverse voltage from 2 to 75 kv.

The units have output currents of 0.2 to 3 amps and are available in configurations ranging from single-phase half wave blocks, center taps and bridges through 3-phase bridges. Voltage density up to 8 kv per linear inch is available.

Dimensions range from 0.5 in. square by 1.0 in. long to 0.75 in. square by 5 in. long.

Circle No. 162 on Subscriber Service Card

Traveling Wave Tube

A traveling wave tube designed for the power-output stage in radar systems is available from the Electronic Tube Div., Westinghouse Electric Corp.

The model WX-5383 has an electrical bandwidth of ±300 mc and can be centered anywhere within the C-band. It has a 40-db. saturation gain with 10-kw peak power. Duty cycle is 0.01. Water requirement for cooling is 0.3 gal. per minute with a pressure drop of 10 lbs./sq. in.

Circle No. 163 on Subscriber Service Card

Crystal Detectors

A series of crystal detectors designed as detecting elements in closed-loop microwave leveling systems is available from Hewlett-Packard Co.

The Model 424A units offer a response flat within ±0.2 db across each waveguide band from 2.6 to 10 gc and ±0.3 db from 8.2 to 12.4 db. SWR is under 1.35 through the X-band. Output impedance does not exceed 15,000 ohms shunted by approximately 10 pf.

Circle No. 164 on Subscriber Service Card

FM Signal Generator

A portable test set for checkout of telemetry and command equipment is being marketed by RS Electronics Corp.

The Model 1021 combines an FM signal source with a 10-channel coder to produce self-coded FM telemetry or command signals, or generate standard IRIG tones for direct testing of decoders.

Plug-in RF heads set frequencies in the 216 to 260- or 400 to 550-mc bands. RF frequency is crystal-controlled. FM deviation is ±200 kc. Input is 28v dc or 117v ac ±10%, 50 to 400 cps.

Circle No. 165 on Subscriber Service Card

Static Inverters

Kinetics Corp. is marketing the S1 series of static inverters, with standard single-phase models ranging from 35 to 700 va. The units met MIL-E-5272 specifications.

The units convert 28-v dc power into 400-cycle, 115-v ac power over a factor range from 0 lagging to 0.5 leading. Overall unit efficiency is flat from ½ to full load. Harmonic distortion is less than 1% nominal and full load, and less than 3% at any condition. Voltage regulation is ±1%; frequency regulation is ±0.5%.

Circle No. 166 on Subscriber Service Card

contracts and procurements

AWARDS

AIR FORCE

$3,000,000—**North American Aviation, Inc., Rocketdyne Div.,** Canoga Park, Calif., for *Altas* missile propulsion systems and related support items.

$2,400,000—**General Electric Co.,** Philadelphia, for work on Mark VI re-entry vehicles.

$1,700,000—**Martin Marietta Corp.,** Denver, Colo., for further research and development on the *Titan II* weapon system.

$1,500,000—**American Bosch Arma Corp.,** Garden City, N.Y., for continued research and development on *Atlas* missile guidance systems.

$1,500,000—**Hughes Aircraft Co.,** Culver City, Calif., for *Minuteman* ICBM checkout equipment and *Titan* ICBM guidance systems.

$1,100,000—**Boeing Co.,** Seattle, Wash., for follow-on work on GSE related to *Minuteman* ICBM sites.

$293,020—**Gulton Industries, Inc.,** Metuchen, N.J., for nickle cadmium batteries.

$167,447—**Parametrics, Inc.,** Waltham, Mass., for research and study of shock-tube lab astrophysics.

$92,811—**Consolidated Electrodynamics Corp.,** Pasadena, Calif., for a spectrometer.

$55,555—**Ramco, Inc.,** Fort Walton Beach, Fla., for modifications to Eglin Range #70.

$39,908—**Aerospace Research Associates, Inc.,** West Covina, Calif., for research on variable geometry structures that absorb and release energy.

$31,982—**Stanford University,** Stanford, Calif., for research on plasma physics and related topics.

$18,658—**Gulf Electric Construction Co.,** Crestview, Fla., for alterations to building #744 at Eglin Air Force Base.

General Atronics Corp., Philadelphia, for design, development and fabrication of a fiber optic recording oscilloscope for the display and recording of scientific phenomena (undisclosed amount).

ARMY

$13,800,000—**International Business Machines Corp.,** New York City, for punchcard machines and computers formerly leased, now to be purchased.

$3,207,166—**C. H. Leavell and Co.,** El Paso, and **Peter Kiewit Sons' Co.,** Omaha, for construction of the largest rocket test stand at NASA's Mississippi Test Center.

$1,500,000—**General Dynamics Corp.,** Pomona, Calif., for further research and development on the *Redeye* missile.

$1,210,656—**Hyde Construction Corp.,** Jackson, Miss., and **Thornton Construction Co., Inc.,** Hancock, Mich., for the construction of various roads, railroads and utilities at NASA's Mississippi Test Center.

$258,000—**Martin Co.,** Orlando, Fla., for modifications of the BIRDIE target data system for *Nike-Hercules.*

NAVY

$9,600,000—**Collins Radio Co.,** Richardson, Tex., for production of airborne data-communications sets.

$8,558,280—**Raytheon Co., Space and Information Systems Div.,** Sudbury, Mass., for production of electronics guidance units for the Mark II *Polaris* missile system.

$6,500,000—**Raytheon Co.,** Lowell, Mass., for follow-on production of *Sparrow* III missiles.

$4,800,000—**Technical Materiel Corp.,** Mamaroneck, N.Y., for communications equipment production.

$3,000,000—**Sperry Rand Corp., Gyroscope Div.,** Great Neck, N.Y., for shipboard missile radar set modifications.

$2,300,000—**North American Aviation, Inc., Autonetics Div.,** Anaheim, Calif., for SINS navigation equipment for *Polaris* systems.

$1,800,000—**American Bosch Arma Corp.,** Garden City, N.Y., for design work related to data collecting/recording gear for use aboard an experimental submarine.

$1,029,000—**Atlantic Research Corp.,** Alexandria, Va., for 550 *ARCAS* meteorological sounding rockets, including payloads and associated support equipment.

$204,000—**ARINC Research Corp.,** Washington, D.C., for a study of the Marine Tactical Data Defense System for air defense.

Control Data Corp., Computer Group, Minneapolis, for 11 additional fire control computer systems to be used aboard *Polaris* submarines (undisclosed amount).

NASA

$2,400,000—**Radiation Incorporated,** Melbourne, Fla., for production of 10 Pulse Code Modulation (PCM) data acquisition and stored program decommutator systems.

$1,356,000—**Blaw-Knox Co.,** Pittsburgh, for design and fabrication of three 85-ft. diameter dish-shaped antenna structures to be used in locating and keeping track of the *Apollo* manned moon mission spacecraft.

$248,349—**Allis-Chalmers,** Milwaukee, for advancement of hydrogen-oxygen fuel cell power supply systems technology.

Rocket Research Corp., Seattle, for the manufacture of two subliming solid control rocket systems (undisclosed amount).

Otis Elevator Co., Brooklyn, N.Y., for production and installation of 31 elevators for Launch Complex 39 at Merritt Island, Fla. (undisclosed amount).

DEFENSE ELECTRONICS SUPPLY CENTER

$137,858—**Fairchild Camera and Instrument Corp., DuMont Laboratories Div.,** Clifton, N.J., for high voltage rectifier tubes for use in ground-based radar early warning systems.

INDUSTRY

$600,000—**Olin Mathieson Chemical Corp., Associated Products Operations,** Marion, Ill., from **North American Aviation's Rocketdyne Div.,** for development of a solid propellant gas generator system for the *Lance* missile.

$500,000—**Acoustica Associates, Inc.,** Los Angeles, from **North American Aviation's Space and Information Systems Div.,** for liquid gaging equipment on the second stage of the *Saturn/Apollo* moon landing rocket.

$70,000—**Correlated Data Systems Corp.,** Glendale, Calif., from **Cal Tech's Jet Propulsion Laboratory,** for five additional solar panel simulators.

Diffraction Limited, Inc., Bedford, Mass., from **Raytheon Co.,** for two telescopes with a magnification of four power for Raytheon laser systems (undisclosed amount).

Diffraction Limited, Inc. Bedford, Mass., from **Spectrophysics Corp.,** for 25 Brewster's angle windows for Spectrophysics laser systems (undisclosed amount).

International Telephone and Telegraph Corp., Industrial Products Div., San Fernando, from **Northrop Norair,** for manufacture of airborne missile launcher power supplies (undisclosed amount).

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Bureau of Naval Weapons
Washington, D.C.

Research and development effort on the MK 18 Mod I guidance control group of the *Sidewinder I-C* guided missile for improvement of performance and reliability. BuWeps intends to solicit a proposal from Philco Corp., Communications and Electronics Div., Philadelphia, Pa., for continuation of a research and development program previously undertaken by the above firm under an existing contract. Note: For information only.

Directorate of Procurement
Rome Air Development Center
Griffiss AFB, N.Y.

A research and development contract is being negotiated with Clevite Corp., Shockley Transistor Unit, for failure mechanisms in silicon semiconductors resulting from an unsolicited proposal. Note: For information only.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Ala.

Furnish all labor and materials for the design and manufacture of three liquid hydrogen level optical sensor systems in accordance with Spec. R-P&VE-PMS-Spec.-4-13 which will be furnished with the RFQ. The procurement will require complete drawings, wiring, wiring schematics, ACD test data for each sensor. Bendix Corp., Pioneer Central Div., Davenport, Iowa, is considered most capable vendor to accomplish task. This company has already completed preliminary design work. Job—RFQ 1-4-50—01088. RFQ due date: 3-23-64.

Development of a low-range absolute pressure calibration system, class 59. The procurement is for the study, development, design and production of a prototype absolute low pressure calibration system. RFQ due date 3-20-64.

NASA Manned Spacecraft Center
General Research Procurement Office
Houston, Tex.
Attn: Daryl W. Chilcutt
Area Code 713, HU 7-7351.

Negotiations will be conducted with Distributors of Precision Instrument Co. for videotape recorder. RFP MSC-64-1090P. Note: For information only. No. RFP available.

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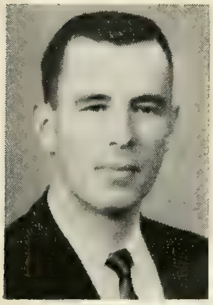
names in the news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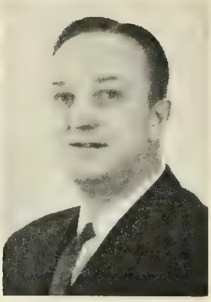
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ELMS

Dr. Karl Hinrichs: Named director of research for the Systems Div. of Beckman Instruments, Inc., Fullerton, Calif.

Dr. John E. Barkley: Promoted to president of the Applied Science Div. of Litton Industries, Minneapolis.

William J. Hill: Appointed director of quality control for CBS Laboratories, Stamford, Conn.

William C. Culver: Appointed government marketing manager for Electronic Specialty Co., Los Angeles.

James C. Elms: Elected vice president and general manager of Raytheon Co.'s Space and Information Systems Div., Lexington, Mass.

Troy Bailey: Joined the Martin-Decker Corp., Long Beach, Calif., as field manager of the Telemetry Div.

William E. Benke: Appointed assistant to the president-marketing of CTL, Studebaker's missile/space technology division, Cincinnati.

George E. Puryear: Appointed manager of Hycon Mfg. Co.'s Dayton, Ohio, office.

Clifford A. Hickman: Appointed marketing manager of Fairchild Space and Defense Systems Div. of Fairchild Camera and Instrument Corp., Palo Alto, Calif.

James C. Nance: Appointed manager of the nuclear pulse propulsion project (Orion) at General Atomic Div. of General Dynamics, San Diego, Calif.

Stephen P. Dillon: Appointed assistant director of operation-Santa Monica for the Douglas Missile & Space Systems Div.

John P. Endicott: Named vice president-finance of Babcock Electronics Corp., Costa Mesa, Calif.

Marvin L. Bookin: Named director of advanced engineering at Data Display, Inc., St. Paul, Minn.

Charles R. Plum: Named director of the Instruments Div. of Aero Service Corp., Philadelphia.

Dr. Richard S. Greeley: Promoted to associate head of the Mitre Corp.'s Intelligence Systems Dept., Bedford, Mass.

Ashley A. Farrar: Appointed vice president-marketing for the Electronics Div. of General Dynamics, Rochester, N.Y.

Dr. Wolfgang K. Berthold: Appointed director of research for ITT Industrial Laboratories Div. of International Telephone and Telegraph Corp., Fort Wayne, Ind.

Paul R. Dolan: Named president of Micro Systems, Inc., Pasadena, Calif., subsidiary of Electro-Optical Systems, Inc.

Robert H. J. King: Appointed director of business development for the Space Systems Div. of Fairchild Stratos Corp., Hagerstown, Md.

Robert H. Malott: Named manager of FMC Corp.'s Organic Chemicals Div., New York City.

Arthur H. Hausman: Appointed vice president-operations for Ampex Corp., Redwood City, Calif.

E. E. Hotchkin: Appointed director of engineering for Data Recorders Div. of Consolidated Electrodynamics Corp., Pasadena, Calif.

George C. Martin: Appointed vice-president-engineering at the Boeing Co., Seattle.

Leonard P. Grady: Appointed director of marketing for Philips Defense and Space Laboratory, Mount Vernon, N.Y.

George F. Anisman: Elected vice president of Menasco Manufacturing Co., Burbank.

William N. Moody: Appointed marketing manager for the Princeton, N.J., division of Electro-Mechanical Research, Inc.

Donald M. MacArthur: Appointed manager-chemical and life sciences center of Melpar, Inc., Falls Church, Va. **Stanley E. Rauch** will head up the electronics-physics research center. **Edward L. Ditz** will manage the space sciences research center.

Richard A. Hayes: Joined the Photronics Corp., Flushing, N.Y., as vice president-engineering.

Thomas J. Sullivan: Elected vice president and director of program management of Hydraulic Research and Manufacturing Co., Burbank, Calif.

Capt. Stewart W. Swacker (USN Ret.): Appointed director of research at Manson Laboratories, Inc., Stamford, Conn.

Wesley S. Melahn: Elected president of the System Development Corp., Santa Monica, Calif., and a member of the Board of Directors.

Dale Myers: Appointed vice president for advanced systems of North American Aviation's Space and Information Systems Div., Downey, Calif.

Larry Cox: Joined Dearborn Electronic Laboratories, Orlando, Fla., as national sales manager.

Hugh A. Brown: Named chairman of the Procurement Review Committee in the Directorate of Procurement, Air Force Missile Test Center, Fla. **Charles W. Swanton** named a contract price analyst.

Frederick B. Cline: Appointed deputy director of the Propulsion and Vehicle Engineering Laboratory, Marshall Space Flight Center, Ala.

William L. Gore: Named senior vice president for sales at Aerojet-General Corp., Azusa, Calif.

Royal S. Foote: Named vice president of Science Management Corp., Denver.

John B. Montgomery: Elected a vice president of Schlumberger Limited, Houston.

Richard J. Hart: Appointed supervisor of tool engineering for the automotive and aircraft divisions of Holley Carburetor Co., Warren, Mich.

when and where

MARCH

Atmospheric Problems of Aerospace Vehicles, sponsored by FAA and AMS, National Aviation Facilities Experimental, Atlantic City, N.J., Mar. 2-5.

15th Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Penn-Sheraton Hotel, Pittsburgh, Mar. 2-6.

Fifth Symposium on Thermal Radiation of Solids, Sheraton-Palace Hotel, San Francisco, Mar. 4-6.

Southeastern Conference on Theoretical and Applied Mechanics, Georgia Institute of Technology, Atlanta, Mar. 5-6.

AIAA Aerodynamic Testing Conference, Marriott Twin Bridges Motor Hotel, Washington, D.C., Mar. 9-10.

National Association of Corrosion Engineers Annual Conference and Corrosion Show, Sherman Hotel, Chicago, Mar. 9-13.

Air Force Cambridge Research Laboratories Exploding Wire Conference, Kenmore Hotel, Boston, Mar. 10-12.

Society for Nondestructive Testing Spring National Convention, Chapman-Park Hotel, Los Angeles, Mar. 16-19.

Pricing and Negotiating Prime and Subcontracts in the Defense and Aerospace Industries Seminar, sponsored by the Contract Management Institute, Ambassador Hotel, Los Angeles, Mar. 16-20.

NBS Symposium on Statistical Association Methods for Mechanized Documentation, National Bureau of Standards, Washington, D.C., Mar. 17-19.

Third Hypervelocity Techniques Symposium, Denver, Colo., Mar. 17-18.

Second Semi-Annual Air Force RTD Procurement Management Seminar, Del Mar Hotel, Santa Monica, Calif., Mar. 18-20.

IEEE International Convention, Hilton Hotel and Coliseum, New York City, Mar. 23-26.

American Meteorological Society National Conference on Physics and Dynamics of Clouds, University of Chicago, Chicago, Mar. 24-26.

Southwest Research Institute Aerospace Bearing Conference, San Antonio, Mar. 25-27.

Technical Symposium, sponsored by Polytechnic Institute of Brooklyn, IRE, AIEE, Army, Navy and Air Force, New York City, Mar. 23-Apr. 2.

APRIL

Society of Plastics Engineers, Engineering with Thermoplastics, Sheraton Hotel, Akron, Apr. 1.

Worcester Polytechnic Institute, Annual Scientific Briefing for Tomorrow, Worcester, Mass., Apr. 1.

Optical Society of America Spring Meeting, Sheraton-Park Hotel, Washington, D.C., Apr. 1-3.

AIAA Annual Structures and Materials Conference, Riviera Hotel, Palm Springs, Calif., Apr. 1-3.

American Chemical Society National Meeting, Philadelphia, Apr. 5-10.

22nd Annual Meeting, National Aerospace Services Association, International Inn, Washington, D.C., Apr. 6-7.

IEEE Rubber and Plastics Industry Conference, Sheraton-Mayflower Hotel, Akron, Apr. 6-7.

IEEE International Conference on Nonlinear Magnetics, Shoreham Hotel, Washington, D.C., Apr. 6-8.

ASME Design Engineering Conference and Show, McCormick Place, Chicago, Apr. 6-9.

ISA Measurement and Control Instrumentation Div. Symposium, Floridian Hotel, Tampa, Fla., Apr. 8-10.

48th Annual Meeting, Federation of American Societies for Experimental Biology, Conrad Hilton Hotel, Chicago, Apr. 12-18.

IEEE Symposium on Microelectronics, Chase-Park Plaza Hotel, St. Louis, Mo., Apr. 13-15.

Institute of Environmental Sciences, Annual Technical Meeting and Equipment Exposition, Sheraton Hotel, Philadelphia, Apr. 13-15.

American Power Conference, sponsored by IEEE and Illinois Institute of Technology, Sherman Hotel, Chicago, Apr. 14-16.

IEEE and ASME International Conference and Exhibit on Aerospace Electro-Technology, Westward-Ho Hotel, Phoenix, Ariz., Apr. 19-25.

ASTME Annual Meeting, Convention and Exposition, Detroit, Mich., Apr. 20-24.

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A Reasonable Man

A PROPER BALANCE of power in the national decision-making process between Congress and such agencies as Dept. of Defense and the National Aeronautics and Space Administration is a delicate thing to maintain.

Inevitably, the balance tips first one way and then the other—amid great expressions of concern from the aggrieved party. Such concern now is being expressed on the Hill, based largely on Secretary of Defense McNamara's refusal to spend money on all the projects Congress would like him to spend it on.

Rep. Leslie C. Arends (R-Ill.) called this to the attention of his colleagues on the House Armed Services Committee the other day in quite vivid terms.

"I feel it my duty to alert the House," he said, "to the fact that power has moved—on tip-toes—from Capitol Hill to the Pentagon and once there, has reached back a friendly hand and issued a smiling invitation to come on over and watch the computers work. It is a disturbing feeling to sit in committee and listen to the recognized military experts of our country state flatly that we need this or we need that and for us to attempt to meet needs through legislation and have the whole thing an exercise in utter futility."

It is true that a continual and deliberate ignoring of the wishes of Congress by the Secretary of Defense can have a very harmful effect.

But it is also true that if the services constantly are permitted to bypass a properly economy-minded Secretary of Defense with appeals to Congress, then the results can be equally harmful.

Thoughtful members of both Houses have sought solutions to this knotty problem. One suggestion is that Congress establish a scientific and technical secretariat all its own—with the implication that it then will have competent technical advice on which to judge the merits of the projects before it. We feel this is not the answer.

What the Congress would wind up with is a lot of scientists convinced they are capable of making political decisions. We have enough of those already.

There also would be another danger from such a scientific panel. It would tend itself to assume the decision-making power in all military and space programs, tipping the balance much too far from proper management by the agencies concerned.

What then is the solution for the harassed committeeman trying to make sensible decisions on complex technical programs? We think it lies in the area of what the legal profession likes to call "the reasonable man."

Congress can obtain competent technical advice from many sources—from private firms involved in the projects, from firms not involved in the projects, from any of the services or many other government agencies.

True, many conflicting opinions may be heard. But in the end, the Congressmen will have to reach the decisions which would be made by the law's reasonable man.

A good case in point is the controversy described on pp. 24-25 of this issue over the requirements for nuclear power units, the SNAP-10A for space and the Pluto reactor—Tory II—for the low-altitude supersonic vehicle (*LASV*), formerly known as *SLAM*.

The Joint Committee on Atomic Energy is quite exercised over the vacillating performances of the Dept. of Defense and the Atomic Energy Commission in regard to the flight-testing of these systems. In view of the millions of dollars which have been invested in development, the committee is questioning the neglect in carrying the projects into flight test.

The Air Force withdrawal of requirements for SNAP-10A after an expenditure of some $100 million seems to be particularly irritating. Funding for Pluto and *LASV* to date has been in the neighborhood of $218 million.

Why in the name of all that is economic, the committee demands, should the Air Force withdraw requirements for the one and refuse to push ahead with the other at this point in time?

IT SEEMS TO US that the committee may be right in the one instance and pressing in the wrong direction in the other. To carry SNAP-10A through a flight-test program would cost an estimated $12 million. Although the Air Force operational requirement has disappeared, we feel this is a reasonable additional expenditure for building-block technology on a unique project where $100 million already has been invested. We remember, for example, when President Eisenhower used the radio-isotopic generator SNAP-3 only as a trick device to turn little lights on and off because there was no military requirement for the unit. Yet, one was found and even today a SNAP-3 unit launched in a Navy navigational satellite in 1961 still is operating in orbit.

On the other hand, it is estimated that even a modest flight-test program for Tory II and *LASV* will cost between $100 and $200 million. This, for a project on which somewhat more than $200 million has been spent to date, is a major milestone.

Dept. of Defense quite properly has called for a breathing spell. From all reports, the program has conclusively shown the technical feasibility of Pluto and is ready to move into the next stage—flight test. But there are major policy decisions to be made. Does the U.S. require *LASV*? Should it be chemical or nuclear? If there is no firm mission requirement, should the program be killed right now before it becomes another *Skybolt* or should it be carried along on back-burner funding for another look at this time next year? DOD must consider all these questions before committing another $200 million to Pluto.

JAEC's concern is quite proper. Mr. Arends' distress over being ignored is equally so. So is Mr. McNamara's determination not to let Congress run his shop for him.

We can only hope that the reasonable man prevails, in these as in other matters.

William J. Coughlin

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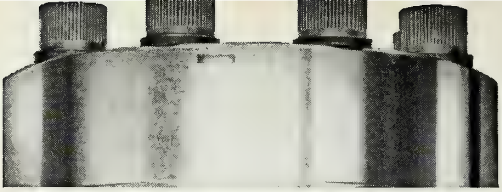

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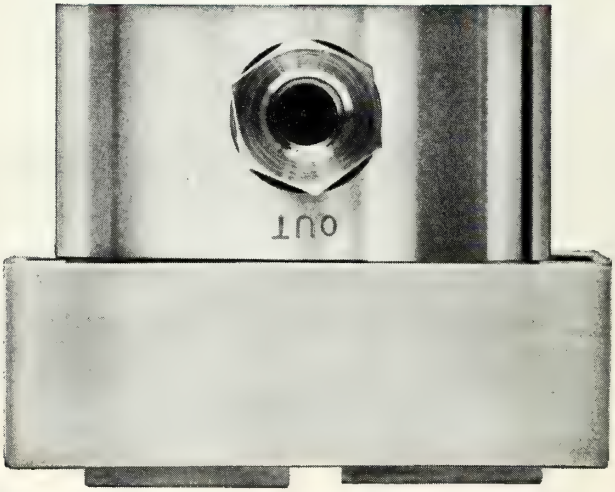

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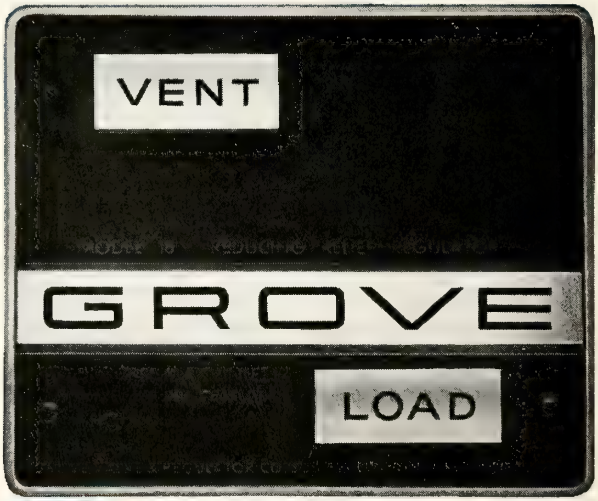

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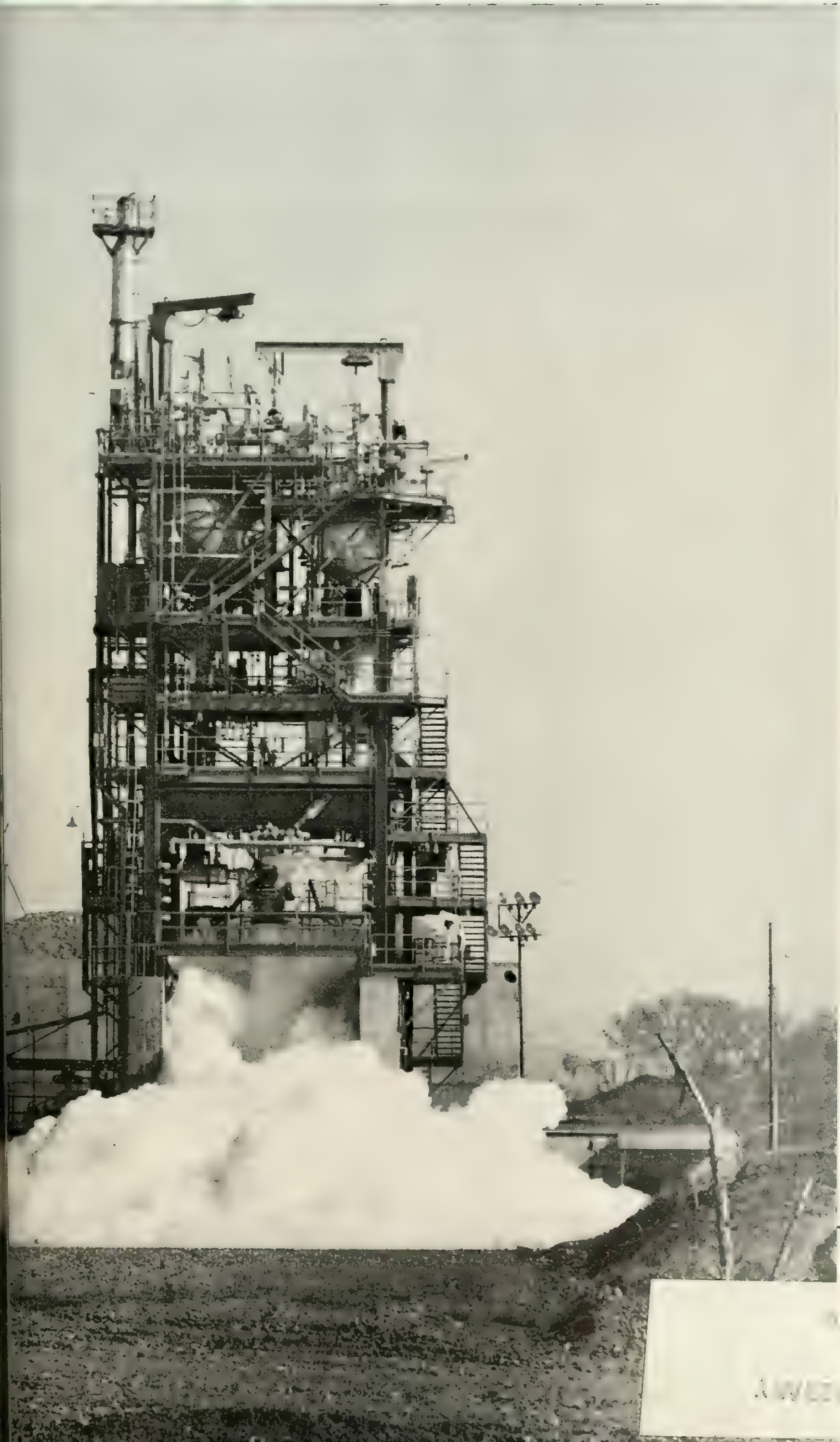


Aerojet Tests M-1 Engine

INSTRUMENTATION NEWS

MILITARY EDITION

Number 1-MI

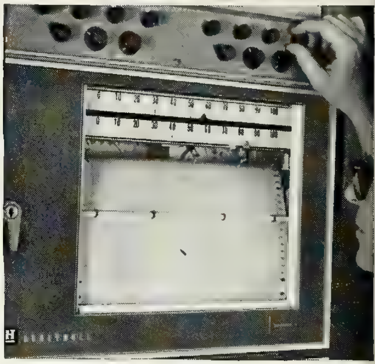
ElectroniK 16 Recorder Introduced

PHILADELPHIA — Honeywell's Philadelphia Division has introduced the *ElectroniK 16* potentiometer, a strip-chart recorder offering many standard features now optional on other recorders.

"The *ElectroniK 16's* modular design concept, along with a number of customer-oriented features that make it convenient to install, maintain and use, makes it the easiest to work with recorder on the market today," said W. A. Forsyth, military market manager for Honeywell's Industrial Products Group.

"For example, the instrument mounts directly into a 19-inch relay rack without using adapters. It has a new, high-performance, transistor servo-measuring unit. Chart-changing time has been reduced to less than a minute. And we can supply an optional pre-loaded chart transport that permits charts to be changed in approximately 10 seconds."

Mechanical layout of the recorder is such, Forsyth said, that most available options and accessories have their own unique location on the chassis. This permits the customer to later add features previously available only as factory-installed or not possible at all if certain other options also were desired.


Operator makes setting on Adjustable Range Unit, optional equipment with two-pen *ElectroniK 16* strip-chart recorder.

"All adjustments can be made simply by sliding the chassis forward," Forsyth noted. "The ink supply can be refilled so easily that the instrument's recording operation is not interrupted. The electrical span and zero controls are made entirely by precision potentiometers specifically designed by Honeywell for this function. And a new type of cam-operated backset switch has been created, again with simplicity of adjustment and stability of operation in mind."

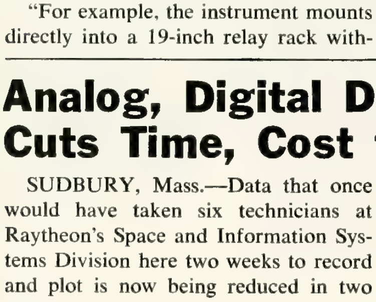
The *ElectroniK 16* is currently available in single-pen, two-pen and multipoint models. Among the options available are an Adjustable Range Unit, chart supply indicator, retransmitting slidewires and event markers. The multipoint recorder has an option whereby any combination of 1 to 24 inputs can be selected by positioning appropriate buttons, and another option giving plugboard selection of alarm points.

WRITE FOR COMPLETE DETAILS

Analog, Digital Data System Cuts Time, Cost for Raytheon

SUDBURY, Mass.—Data that once would have taken six technicians at Raytheon's Space and Information Systems Division here two weeks to record and plot is now being reduced in two hours by one man.

Behind this 168 to 1 time compression is an automatic Honeywell analog and digital data processing system. Designed and built as an Air Force modernization facility from standard components by Honeywell's Special Systems Division, it can record, for selective playback and readout, up to 230 channels of data from 11 remote test areas.


Raytheon lab manager Elmo Pacini checks Honeywell Model 1108 *Visicorder* oscillograph as it monitors wave shape of 24-channel vibration test data.

The analog portion of the system receives data from one shock test area and five vibration test rooms. The digital system handles temperature, barometric pressure and air flow data from five climatic environmental test chambers.

Primary inputs for the analog recording sub-system are 24 accelerometer signals, recorded simultaneously on two-inch FM tape. Wave shapes can be monitored with a Honeywell Model 1108 *Visicorder* oscillograph. Also recorded are shake table frequency, vibration servo control output and voice for a total of 27 analog channels.

The playback sub-system, using the same Honeywell tape transport as the recording network, plots rectified acceleration level vs. frequency on an X-Y plotter in log-log or log-linear form.

The digital system scans at 100 points per minute, measures, linearizes, digitizes and records up to 200 inputs from thermocouples, turbine flow meters and pressure transducers.

Information is fed into a Honeywell ADRT 3200 data logger having an incremental tape recorder. This recorder stores up to 72 hours of 200-channel data on one 2400-foot roll of half-inch tape.

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Volume 14, Number 10 March 9, 1964

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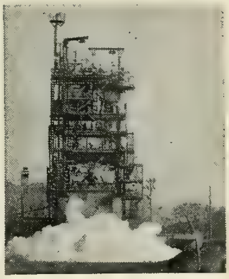

Aerojet-General conducts cold-flow test of liquid oxygen in 1.5-million-pound thrust development chamber for NASA's M-1 rocket engine. Hot firings are next for the powerplant, which is being developed as the nation's most powerful hydrogen engine to boost the big payloads the U.S. will need after first lunar flights.

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letters

Ranger Management

To the Editor:

Congratulations on your Feb. 10 editorial. It's about time that men with and of your resources open the "right" people's eyes.

Judging by the record of *Ranger*, JPL is wasting our tax money. Therefore JPL should be relieved from any future responsibility in critical space programs.

H. F. Baumgartner
Canoga Park, Calif.

To the Editor:

Re: your editorial analysis Feb. 10.

I second the motion!

R. Judy
Santa Monica, Calif.

To the Editor:

If you really think that the academic and research atmosphere at the California Institute of Technology is, as described in your Feb. 10 editorial, "leisurely," then as a graduate of that institution I will tell you this: Your remark may or may not be completely knuckleheaded, but it certainly does not represent an informed point of view.

Willard A. Dodge, Jr.
Pacific Palisades, Calif.

To the Editor:

Re your editorial dated Feb. 10 ("The $150-Million Failure").

Please cancel my subscription. I don't want your magazine in my home.

Are all of your facts so far from right?

C. L. Steadman
Jet Propulsion Laboratory
Pasadena, Calif.

Kiwi Funding

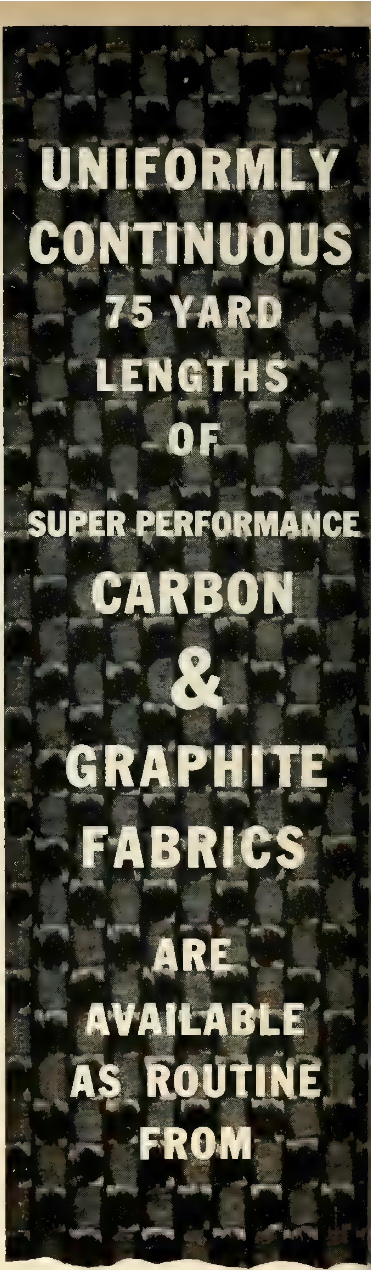
To the Editor:

I read with interest your article, "NASA Seen Blocking Electric propulsion" (M/R, Feb. 10, p. 24) and feel that I must call to your attention: 1) that the Kiwi program is *not* eliminated and, quite the contrary, is very much alive, and 2) that Kiwi funding has always come from the AEC.

LASL cold-flow tested a Kiwi B-4D on Feb. 13, and it appears that vibration problems are licked. Hot tests of a Kiwi B-4D and a Kiwi B-4E should be held sometime before mid-year, and the *NERVA* contractors are planning a cold-flow and hot tests of NRX before mid-year.

Peter Mygatt
Public Relations Office
Los Alamos Scientific Laboratory
Los Alamos, N.M.

Reference was made to the Fiscal Year 1965 budget, in which period Kiwi will be phased into NERVA.—Ed.



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Boston Center

To the Editor:

In answer to your Feb. 17 editorial ("That Boston Center"), I wish to inform you that the need for research centers and laboratories arises from the sloppy and faulty work performed by private commercial concerns that sell and supply items for the defense of our country.

I have close contact with private concerns and so far have met few that have shown a sense of patriotism and responsibility for their country. It is becoming more and more apparent that private concerns have only one attitude toward their government, and that is to extract as much money for less and as often as they can. Proof of these statements can be made by the tragic loss of the "Thresher" and so many missiles that have failed because of faulty items manufactured and installed by money-hungry manufacturers.

You speak of free enterprise, but your first and last obligation should be your country and its defense against the people who would destroy all that we have now. Your statement about "swollen parasites" on the free enterprise system is uncalled for and downright unpatriotic.

I have worked for the U.S. Army since 1958 and have witnessed the irresponsibility of private concerns; you should be calling them "swollen parasites." As for you, Mr. William J. Coughlin, as sure as there is a God in the Heavens, you will receive your just reward.

Hyke D. Markarian
Waltham, Mass.

Disneyland?

To the Editor:

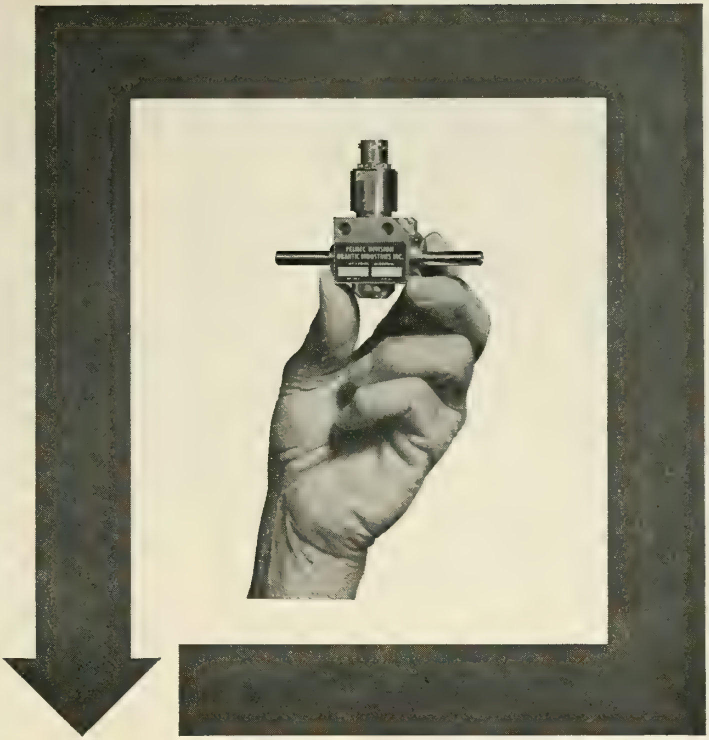
For months now, I have been reading Letters to the Editor, pro and con, on the Cape Canaveral name change. The latest concern of your readers, it seems, involves petty bickering as to who is qualified to judge whether the change is appropriate or not. Are length of residence, knowledge of history, political preference, and word interpretations now prerequisites for determining if alteration or outright abolition of an internationally known landmass name is justified?

"Cape Canaveral" is as traditional to America as "Times Square," "Grand Canyon," "Squaw Valley," or "Disneyland," To destroy its name, now or ever, is approaching the similarity of tactics employed by the Ministry of Truth in George Orwell's *1984;* eradicating names of persons, places, and things without a trace.

Let us put a "Kennedy Missile Test Center" on Cape Canaveral, but let us not mold our landmark nomenclatures into palimpsests as the non-democratic countries do.

Richard B. Cooper
University of Tampa
Tampa, Fla.

We suspect that the nation—all the way from New Amsterdam to Boulder Dam—will survive the Canaveral-to-Kennedy name change.—Ed.



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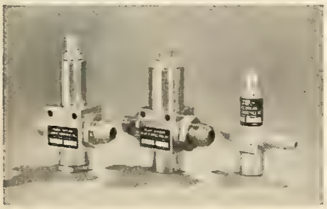
But before you get (pardon the pun) all fired up about the Model 1128, you should see some of the others we've put in orbit. They're available in sizes ¼″ to ¾″ and larger, in any material, for any environment, pressure-proof to 10,000 psi and beyond. For low-pressure details, drop us a note today.



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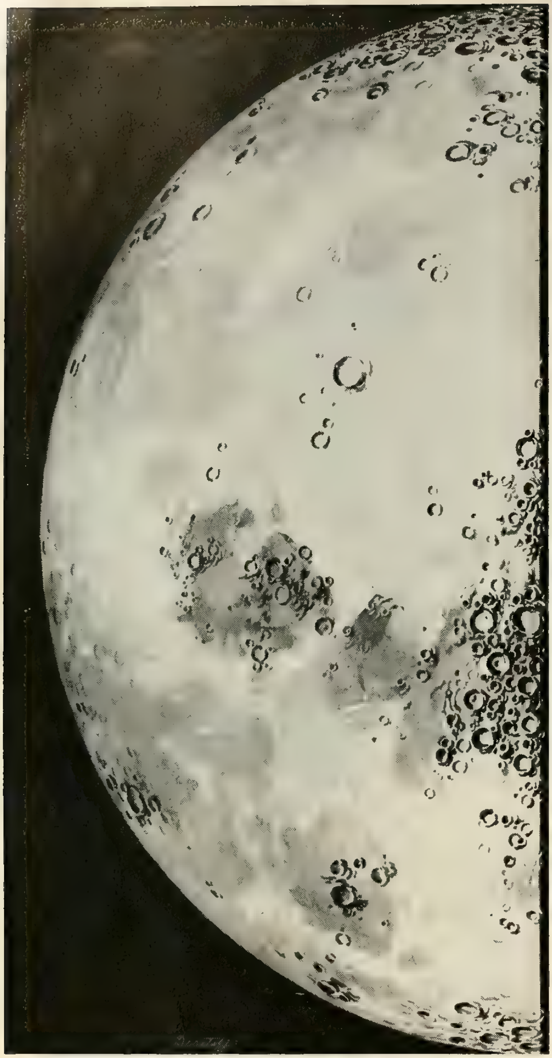
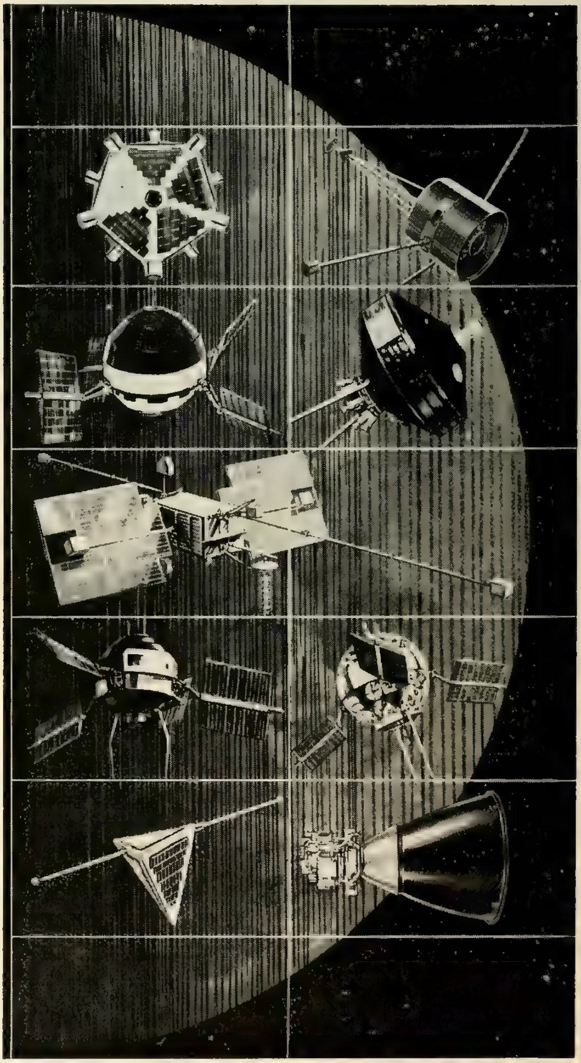


TRW SPACE TECHNOLOGY LABORATORIES In Perspective



As the nation's first industrial firm devoted exclusively to missile and space technology, TRW Space Technology Laboratories grew with the national space effort. Since 1957, STL has participated in nearly every manned and unmanned space probe.

Today, 2500 engineers and scientists and 4500 support personnel combine their talents on many STL projects ranging from research and development to design and manufacture of NASA'S OGO spacecraft, Air Force nuclear test detection spacecraft, Tetrahedral Research Satellites, and NASA'S Pioneer spacecraft.

Also underway is the development of the variable-thrust rocket descent engine for LEM, the Lunar Excursion Module of Project Apollo. At the same time STL continues Systems Management for the Air Force's vital Atlas, Titan and Minuteman Programs.

These many space activities create immediate openings for engineers and scientists with experience in Theoretical Physics, Systems Engineering, Radar Systems, Experimental Physics, Applied Mathematics, Space Communications, Space Physics, Antennas and Microwaves, Inertial Guidance, Analog Computers, Solid State Physics, Computer Design, Telecommunications, Digital Computers, Guidance and Navigation, Electromechanical Devices, Engineering Mechanics, Applied Aerodynamics and Propulsion Systems.

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***TRW* SPACE TECHNOLOGY LABORATORIES**
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The Countdown

WASHINGTON

Bullpup Follow-on Is Sought

An all-weather, extremely accurate tactical air-to-surface missile is high on the Air Force shopping list. Immediate problem: to demonstrate feasibility of a system superior to those now available. In-house studies have suggested several approaches which may lead to definition of a missile or family of missiles to fill the requirement.

Navy Reveals MISER Program

A ship-to-ship and ship-to-shore relay system using communications satellites is under advanced development by the Navy. Dubbed MISER, the program calls for procurement and evaluation of a shipboard terminal during the coming year. Presumably, MISER is based on Navy work on LOFTI (VLF) experiments, which have been very successful.

Titan III May Get Nod for SNAP 50 Test

If it ever reaches that stage, SNAP 50 is likely to be flight-tested on *Titan III*, Air Force officials believe. But *Saturn* remains another possibility. Weight of SNAP 50 will be approximately 20,000 lbs. (20 lbs./kilowatt). Air Force is enthusiastic about the program and feels that *Manned Orbiting Laboratory* or its successors will require SNAP 50-type devices.

NASA Exonerates Titan in Gemini Slippage

NASA officials now acknowledge that further delay in the first unmanned *Gemini* flight cannot be blamed on slippage in the recent static firing of its *Titan II* booster (COUNTDOWN, March 2, p. 9). Word from the Cape is that the shot still is scheduled for March. Slippage into April is regarded as almost certain, however.

Nuclear Power Seen for Satellite Inspection

Air Force studies indicate nuclear rockets may be an answer to the difficult problem of satellite inspection. With almost twice the thrust capability of chemical vehicles, nuclear inspectors would be able to make appreciably more inspections per launch. The higher specific impulse also would allow greater orbital changes per amount of propellant.

Project Orion Is Still Alive

Interest continues in Project *Orion*, which would provide propulsion for a spacecraft through a series of small nuclear explosions. Marshall Space Flight Center is expected to award a study contract on the concept in Fiscal '65. Despite still formidable technical and political problems, the approach is regarded as promising.

The Million-Dollar Misunderstanding

Members of the House Manned Space Flight subcommittee recently asked a NASA official how much the space agency was spending on *Nova* studies. His reply: $50,000. While that answer may be technically correct, he forgot to mention the $1-million study contract the space agency is negotiating with Martin Co. to study post-*Saturn V* launch vehicles—previously known as the *Nova* program.

Report on Ranger VI Failure Is Due

A report on cause of the malfunction which blacked out *Ranger VI* television transmission is imminent. NASA and industry officials met in Washington last week to firm up their findings. Major attention has been centered on the premature telemetry transmission. Incidentally, none of the 32 observatories which attempted to see and photograph *Ranger VI's* lunar impact succeeded. At the two observatories in the best position—Kitt Peak at Flagstaff, Ariz., and McDonald at Alpine, Tex.—film packs jammed.

NASA To Award Lunar Surface Study

Manned Spacecraft Center is preparing to award a $100,000 study of how astronauts can perform lunar survey measurements after landing on the Moon. The six-month study will seek answers on how the size and shape of the Moon can be established and how points on the lunar surface can be located for the purpose of future navigation.

Senate Looks at Electronic Center This Week

On Tuesday, the Senate Space Committee will meet on NASA's proposed Boston electronics center. Space agency Administrator James Webb has offered to hold off any action until all the committee's questions are answered—regardless of expiration of the 45-day deadline by which Congress must act if the center is to be vetoed.

INDUSTRY

Chrysler Gets Additional Saturn Contract

Chrysler Corp. has been awarded an additional $16-million contract for modifications to the work it will perform on its *Saturn I* and *Saturn IB* first-stage production contract. New money will cover expanded booster reliability testing and engineering support activities.

Contracting for Gemini X Outlined

Contracting arrangements for the *Gemini X* program have been disclosed. Air Force is negotiating a contract with McDonnell Aircraft to study reqirements of the blue-suit *Gemini*. If the capsule is sufficiently similar to NASA's version, the space agency will do the contracting for the Air Force. If not, AF will handle its own contract.

INTERNATIONAL

French Plan Own Tracking Network

The French Centre National d'Etudes Spatiales (CNES) has commissioned Compagnie Française Thomson-Houston (CFTH) to provide initial equipment for an all-French tracking network. Space officials there boast it will be superior to Minitrack, the U.S. net.

Swedish Army Orders Bantam Missile

Combat and training versions of the *Bantam* antitank missile have been ordered by the Swedish Army in a $3-million contract with AB Bofors, Swedish armament and chemical firm. *Bantam* is a wire-guided missile with a range of 1.5 miles. Similar in concept to the U.S. *TOW* missile, it now undergoing service testing in Sweden.

The Missile/Space Week

Singer Leaving Weather Bureau

Dr. S. Fred Singer, director of the National Weather Satellite Center since its inception in 1962, has resigned to head the nation's first school of Environmental and Planetary Sciences at the University of Miami.

David S. Johnson, Deputy Director of NWSC, will move into the position of director. Johnson was instrumental in establishing the Meteorological Satellite Laboratory and was its director until it became the Satellite Center.

Singer most recently participated in the planning of an interim meteorological satellite system based on *Tiros* technology. This is expected to consist of two satellites in polar circular orbit. The new satellites, of a cartwheel type, will have subsystem redundancy to increase lifetime.

Hughes Gets ATS Pact

NASA has selected Hughes Aircraft Co. as prime contractor for the *Advanced Technological Satellite* (*ATS*) program.

The incentive contract, covering development of five spacecraft, will be worth more than $30 million. Flights will begin in 1966.

Hughes recently completed a 21-month feasibility and preliminary design study based on the successful development of the *Syncom* synchronous orbit communication satellite.

Investigations to be undertaken on the *Advanced Technological Satellite* include meteorological sensors and components, radio frequency propagation measurement, Earth-pointing antenna systems and radiation measurements.

ATS will be a cylindrical structure weighing about 650 lbs. to be launched by an *Atlas-Agena* from Cape Kennedy. It will carry a variety of experimental instruments weighing from 100 to 300 lbs., depending on the mission.

Three types of missions are planned for *ATS*:

—a 6,500-mi. Earth orbit to experiment with a gravity-gradient stabilization system. Several long booms will extend from the spacecraft to interact with the Earth's gravitational field to stabilize the satellite and align it toward Earth.

—two synchronous 23,500-mi. Earth orbits with the *ATS* spin-stabilized to make meteorological, communications and navigational investigations.

—two synchronous Earth orbits using the gravity-gradient stabilization system to make engineering and technological studies.

SECOR Touted for New Role

Cubic Corp., San Diego, Calif., developer of the *SECOR* satellite system for accurate ground mapping, is proposing an extended system of this type to NASA for interplanetary position fixing. With one transmitter on the Moon and another on Earth, the extended system would provide accurate navigational guidance for interplanetary probes. The station on the Moon could be an automatic soft-landed package or could be set up by an astronaut.

C. J. Breitwieser, executive vice president of Cubic, says that the *SECOR* system (M/R, Feb. 24, p. 10) which requires a 7-lb. transponder in the space vehicle, also has very real potential for orbital rendezvous work. It could provide accurate tracking data for initial rendezvous maneuvers.

The present *SECOR* system is being developed by the Army Corps of Engineers. Tests with a 600-mi.-high satellite are being made from 1-kw transmitters at Fort Carson, Colo., Las Cruces, N.M., Stillwater, Okla., Austin, Tex., and Grand Forks, N.D. Each station in turn acts as the unknown and its position is measured with respect to the others. Unofficial reports suggest that accuracies better than 30 meters are being obtained.

Future expansion of this program would probably call for establishment of a ground station in Alaska and, ultimately, Hawaii.

Echo II Status Report

The *Echo II* passive communications satellite has been successfully used for the transmission of radio signals and telephone speech between Britain's Jodrell Bank Observatory and the Soviet Union's Gorki University Radio Astronomy Station.

The transmission of radiophoto experiments was also scheduled between the two stations.

Echo II orbits the Earth every 108.8 minutes at a perigee of 633 statute miles and an apogee of 820 miles.

Shots of the Week

The Navy on Mar. 2 successfully fired a *Polaris A2* missile from the nuclear submarine Woodrow Wilson, submerged off the Florida coast. The steam-launched shot was the first to be conducted from the Wilson.

- The Air Force launched a *Thor-Agena* from Vandenberg AFB, Calif., Feb. 27. The booster carried a payload of undisclosed type.
- An Air Force *Minuteman* missile was launched Feb. 27 from Cape Kennedy on a routine 5,000-mile flight to the splash net near Ascension Island. The Air Force said the flight was a complete success.
- On Feb. 28, Army artillerymen completed a series of four *Pershing* shots from Ft. Wingate, N.M., into the White Sands Missile Range. The first two shots on the 24th (M/R, Mar. 2, p. 12) were successful. A Feb. 25 shot failed, but the firing of the 28th was successful.

Nike-X Award Let

Western Electric Co. has received a $70.6-million major contract from the Army for research and development in support of the *Nike-X* program.

More than $22 million of this sum will go to Bell Telephone Labs in Whippany, N.J., and more than $10.3 million is to be spent in Western plants in Greensboro, Winston-Salem and Burlington, N.C.

Johnson Reveals A-11 Missile

An experimental fire control and air-to-air missile system for the A-11 aircraft was revealed by President Johnson in his February 29 news conference.

However, in making his surprise announcement of the existence of the Mach 3 interceptor, the President just as quickly dropped the curtain of secrecy back over the entire subject. He would not discuss the A-11 program any further, he said, and he publicly cautioned other officials not to discuss the project.

It appears likely that the missile system described by the President is an outgrowth of the *Falcon* family of air-to-air missiles developed by Hughes Aircraft Co. The company had been working on similar components for the F-108, an Air Force interceptor, before that program was cancelled. After the interceptor cancellation, Hughes was permitted to continue work on the fire control and missile system designated *GAR-9* (new designation *AIM-47*).

Part of the *Falcon* family, the *GAR-9* was designed for launch from high speed airborne platforms such as the A-11. At the time of the F-108 cancellation, over $200 million had been spent on the system—$70 million of that amount on the fire control system.

The fire control system is believed to be the AN/ASG-18, which the Air Force has carried on its books under Advanced Development. Propulsion for the AIM-47 is provided by Lockheed, a departure from the other members of the *Falcon* family. These used Thiokol motors. Lockheed is prime contractor for the A-11.

AMC Gets New R&D Center

The Army Missile Command's new research and development center at Redstone Arsenal will be dedicated March 12.

The facility will be named for Francis J. McMorrow, the major general who headed the Army Missile Command at the time of his death last year.

Col. Nickerson Dies in Collision

Army Col. John C. Nickerson, a key figure in the 1957 fight over the Department of Defense decision to limit the Army to development and use of short range missiles, was killed in an automobile accident Mar. 1 near Alamagordo, N.M.

The colonel was stationed at Ft. Bliss, Tex., at the time of the accident.

Nickerson's wife was also killed in the wreck, and his two sons were injured.

Comsat Files with FCC

Communications Satellite Corp. expects to construct and place into orbit a synchronous communications satellite by spring, 1965.

The first satellite would be experimental, but would provide service between North America and Europe. Global service from a more advanced system is planned by 1967.

In an application to the Federal Communication Commission, Comsat asks approval for construction and launch of a 240-telephone-circuit satellite into synchronous orbit. The satellite would have an alternate capacity for message traffic, facsimile or black and white television.

Also sought in the application is approval (as required by the Communications Satellite Act) of the satellite's technical characteristics.

The first satellite is to weigh 150 lbs. at launch and 85 lbs. in orbit, after expenditure of fuel and motor. Launch would be from Cape Kennedy with a thrust-augmented *Thor-Delta* booster.

The communications repeater in the satellite is to be compatible with ground stations already in use or under development.

Ball Bros. Get OSO Award

Ball Brothers Research Corp. has received a preliminary $800,000 NASA contract to begin construction of the last five of the eight planned *Orbiting Solar Observatories* (*OSO*).

Ball has already built two of the eight satellites, and is working on a third. One *OSO* has been flown, and plans call for the launch of two more before the end of the year.

The five *OSO* satellites covered by the new contract will be launched at nine-month intervals beginning in early 1966, according to NASA. They are intended to study the solar cycle through the periods of increased activity during the late 1960s. The previously contracted *OSO's* are slated to participate in the current International Year of the Quiet Sun by taking X-ray and ultraviolet radiation measurements of the Sun.

Polaris Reliability Praised

Secretary of the Navy Paul H. Nitze says that *Polaris* submarines presently on duty are practically invulnerable to enemy attack and could, by themselves, account for a retaliatory kill of 25 to 35-million persons.

The claim was made in a letter to Rep. George Mahon (D-Tex.), Chairman of the House Appropriations Defense Subcommittee, who recently questioned Nitze regarding the reliability of the *Polaris* system.

Nitze said he based his estimate of the weapon system reliability on the product of compiled figures on alert, launch, flight and warhead reliability.

The Secretary quoted Vice Chief of Naval Operations Adm. C. V. Ricketts as saying that since the first *Polaris* sub went on duty over three years ago, ". . . no *Polaris* has been late in deployment; no patrol has been aborted; no submarine has returned early from its patrol; no communication message has been missed. Over 99% of the time at least 15 of the 16 missiles (in a typical submarine) have been ready for firing and all 16 missiles have been ready for firing over 95% of the time."

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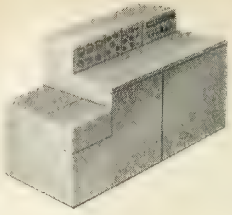
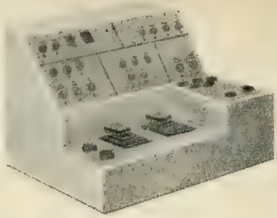
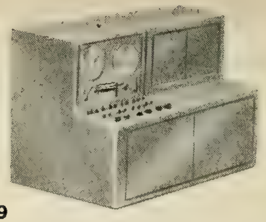


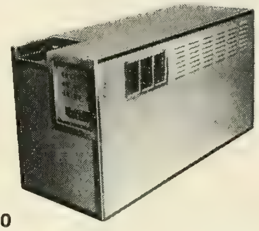
1947
VALE I. One of the earliest applications of digital computation.



1948
DIDA. First digital differential analyzer.

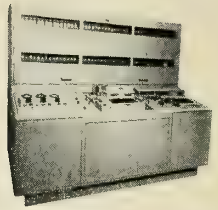


1949
VALE II. A more automated VALE I with card input.

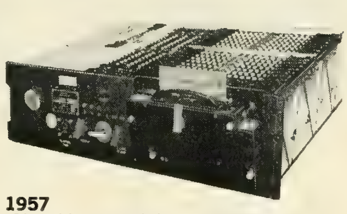


1950
MADDIDA. First digital differential analyzer with magnetic drum memory.

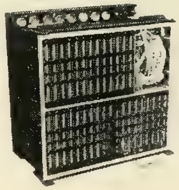
1951
QUAC. Digital computer with rotating magnetic drum memory and card-fed input which generated a quadratic arc.



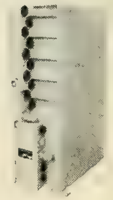
1955
GFC. A highly specialized ground-based digital computer for the first intercontinental missile.



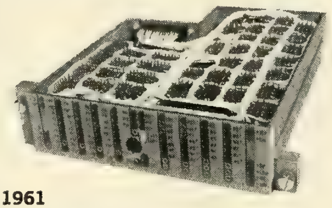
1957
APAC. Airborne parabolic-arc computer. First all-solid-state missile-borne digital computer.



1959
LINC. Lightweight inertial navigation computer. A hybrid with plug-in modules and a component density of 20,000 per cubic foot.

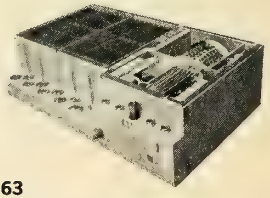


1960
GAM-87A Prelaunch. An advanced hybrid with a 500,000-bit memory and the greatest computational capacity of any aerospace computer.



1961
Mark IV SINS. Polaris submarine-borne computer. Welded modules, plug-in trays, 35,000 components per cubic foot.

1961
Ranger Central Computer and Sequencer. Built to JPL design for Ranger Blocks I through III.



1963
CP-720. Navigational airborne data processor. An advanced hybrid for AN-USQ-28 geodetic mapping and survey system.

It took us 17 years

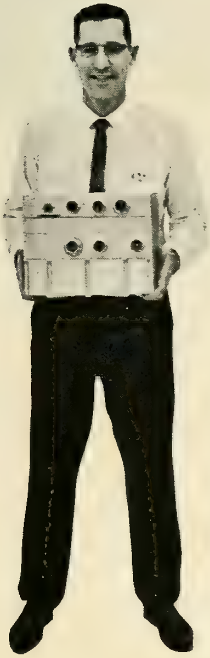
A long time? Not really.

The modern computer industry is only 17 years old. It was born about the time that Northrop engineers invented the digital differential analyzer and combined it with a magnetic-drum memory to create the first truly compact computer.

We've always made small computers. With big capacity. Small because most of them were designed to fly. Big capacity because they were the brains of the most complex military and aerospace systems.

We're in the systems integration business, and we've developed our computers to meet systems requirements. Each one has been at the limits of the state of the art. Some have been breakthroughs.

The computer on the right is the NDC-1000, now in the final stages of development. It's designed to be an off-the-shelf item for many military and aero



to build this computer.

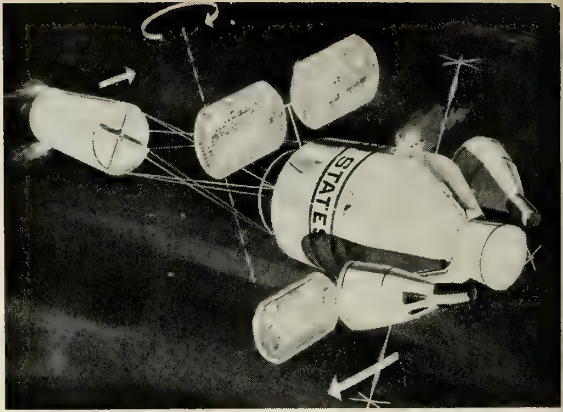
space applications. It will package the equivalent of nearly a million components into less than one cubic foot. Its problem-solving capability will match the argest ground-based computers. It will accept all types of inputs, deliver any desired readout. It will function dependably in all military and spacecraft environments.

The NDC-1000 is the closest thing to a "stock" computer we're likely to build. But we'll keep right on designing computers to integrate systems. They'll get smaller and lighter, faster and more versatile. They will be rugged and reliable, and they will check their own condition. They will incorporate all the sophistication that our computer specialists have acquired over the years since the world began.

The computer world, that is.

NORTHROP NORTRONICS

New NASA/DOD group . . .



ONE OF DOUGLAS space station concepts is shown in recent drawing.

Panel Shaping Space Station

by Hal Taylor

A SPECIAL PANEL has been established by the Johnson Administration to recommend the best configuration for the National Space Station program.

The group, formally approved on March 2, is named the National Space Station Planning Sub-Panel of the joint NASA/DOD Aeronautics & Astronautics Coordinating Board (AACB).

Informed sources say the panel will make its report in "a matter of months."

The schedule was confirmed by Dr. Edward C. Welsh, acting chairman of the National Aeronautics and Space Council, the White House's space advisory group.

"I attended the March 2 meeting and I would say that a recommendation would be made later this year," Welsh told MISSILES AND ROCKETS.

The White House official was far less sure, however, of when development of a national space station might begin.

"I would expect a start soon after the recommendation is made," Welsh said, "but nobody really knows at this point. In part, it will depend on what the recommendation is."

The "go/no go" decision is certain to be put off until after November's presidential election. Approval of the development program before the election would simply be an exercise in frustration if the Johnson Administration were turned out of office. Any new administration probably would review the whole U.S. space program, including the space station project, meaning further delay in its initiation.

The six-man sub-panel will be headed by co-chairmen Dr. Michael Yarymovych of NASA's Advanced Manned Missions Office and Col. Kenneth Schultz, Deputy Director of the Development Planning for Space, Headquarters, USAF.

Other NASA representatives are Richard Wisniewski, chief of Advanced Vehicle Conceptual Studies, and Willis B. Foster, director of the Office of Manned Space Science.

The other DOD officials on the subpanel are Starr Colby, Assistant Director for Space Technology in the Office of Defense Research and Engineering, and Col. John L. Colter, USAF.

- **Assignment**—Broad responsibility of the group is to implement the NASA/DOD agreement to make maximum use of Earth-orbital studies in establishing the requirements and objectives of both agencies in the National Space Station program.

It will seek to determine the optimum configuration for the space station, its estimated cost and which agency should manage the project.

Work tasks include:

—Review developments in the program and recommend the necessary concepts which will maximize use of existing hardware for the National Space Station program.

—Develop an integrated plan of studies which establishes the feasibility, cost and operation of a National Space Station program which will meet the long-range goals of NASA and DOD.

The sub-panel will make its report to the AACB. From there, it will be passed along to NASA Administrator James E. Webb and Secretary of Defense Robert S. McNamara.

The panel will have no responsibility for, and will not consider, the Air Force's *Manned Orbiting Laboratory (MOL)* project.

The group has been meeting informally since October, 1963, but was not formally set up and given responsibility for the project until last week.

It has already coordinated and approved NASA's space station study program for Fiscal 1964.

- **Douglas pushes ahead**—An important part of the space agency's program was finalized recently with the signing of a $1.4-million contract with Douglas Aircraft Co. for a follow-on study of the NASA *Manned Orbital Research Laboratory (MORL)* concept.

Last year, Douglas completed a three-month *MORL* study contract which led to the new award; in December the firm was selected to negotiate the contract just signed.

The new six to 9-month contract will be managed by the Langley Research Center's Manned Orbiting Laboratory Studies Office, headed by William N. Gardner, under the overall direction of NASA's Office of Manned Space Flight. Basic research on the technology of a manned orbiting laboratory has been in progress at Langley for several years.

In its study, Douglas will refine the NASA concept of an orbiting laboratory which assumed a cylindrical six-man spacecraft capable of being launched by the *Saturn* rocket. The feasibility of using equipment to provide intermittent artificial gravity for the spacecraft crew, and the feasibility of launching both ferry and supply spacecraft on a single vehicle will be examined.

The study program will also continue on the *Extended Apollo* concept, which could increase the spacecraft's orbital operations capability up to one year. In this area, the agency has still not decided whether to award a separate study of the laboratory module, which might be part of the extended spacecraft concept. ■

To House Space Committee . . .

NASA Explains Choice of Boeing Over Hughes in Lunar Orbiter Award

MEMBERS of the House Space Committee appear to be satisfied with NASA's contracting policy on the *Lunar Orbiter* award, but probably will turn over another contract to the General Accounting Office (GAO) for investigation.

Award of the *Lunar Orbiter* to the Boeing Co., which submitted a bid of $83 million—said to be almost twice as high as that of Hughes Aircraft Co.—was questioned by Rep. Earl Wilson (R-Ind.).

According to Rep. Joseph Karth (D-Minn.), chairman of the Space Sciences Subcommittee which handles the lunar and planetary program requests: "On several occasions during the hearings we probed deeply into the question, involving the contract to Boeing."

Karth indicated that the subcommittee was satisfied with NASA's answer, which was that Boeing's proposal was selected because of its three-axis system rather than the spin-stabilized system suggested by Hughes. Although the Boeing spacecraft would cost more, the photographic system for the spin-stabilized system brought up problems more difficult than those of the three-axis system. "After all, the only objective of *Lunar Orbiter* is to take pictures of the lunar surface," Karth pointed out.

He indicated that the subcommittee felt that one decision was perhaps not significantly better than the other, but that the three-axis approach showed enough additional merit to be worthwhile.

The subcommittee reported that it was not attempting to pass on the technical merits of the decision, but that it was generally "satisfied" with NASA's assurance that the system was best, and would "wait and see what happens."

Chairman George P. Miller (D-Calif.) of the House Space Committee told reporters that the full committee would take up the subject only if evidence were produced to justify it.

• **Investigation**—Several questions on NASA contracting policies raised in the Manned Spaceflight Subcommittee resulted in closed-door hearings with procurement and program witnesses.

Given particular attention was a "housekeeping" contract to Mason-Rust Company. Rep. Olin Teague (D-Tex.) told M/R the committee is considering asking the GAO to look into it.

The Congressmen questioned the contract because, while Mason-Rust was first selected after competition to perform such duties as fire protection, medical operations and janitorial services, an additional facet was added which gave the company the job of managing construction.

This resulted in Mason-Rust's choosing the architects, arranging for bids and doing all the supervising on the construction of a building reported to be worth about $8 million. ■

$6.75 Million Requested For Geodetic Satellite

NASA is asking $6.75 million for a new geodetic satellite, which it informally is calling *Geos*, although it has no official name yet.

Space Sciences chief Dr. Homer Newell says NASA will prepare the satellite and instrument it to cover the observing needs of the agency and the Departments of Defense and Commerce. This may include flashing-light electronic instrument requirements, and any laser reflectors.

The user agencies are expected to fund their own ground stations and observing programs.

The Army's *SECOR* (Sequential Collation of Range) is a contending system for the new satellite, but will not necessarily be carried. Newell said that NASA has since done much work at Goddard Space Flight Center, and that many systems are in competition.

In addition, he said, the ionospheric beacon satellite has carried laser equipment for optical tracking measurements, with geodetic programming in mind.

A policy planning board at NASA headed by Dr. John Naugle meets regularly with the Department of Commerce and DOD, and oversees a working group which is developing plans for the satellite.

Space Agency May Alter Weather Satellite Policy

NASA probably will switch to a prime contractor for meteorological satellite systems when they reach the operational stage, space agency officials told Congress.

The unique practice of allowing the Goddard Space Flight Center to manage the meteorological satellite program "in-house" was adopted because, at the time, the agency was reaching far beyond the state of the art. Edgar M. Cortright, deputy associate administrator for Space Sciences and Applications, explained this last week to the Space Sciences Subcommittee of the House Space Committee.

In the *Nimbus* program, it finally was decided to award an integration contract to industry. The subcommittee questioned the possible inefficiency of the in-house approach, to which NASA replied that it had decided to switch when the programs became operational.

Dr. Homer Newell, Cortright's superior, also disclosed that the Weather Bureau's decision to pull out of the *Nimbus* program in favor of an operational interim *Tiros* program has left NASA with one *Agena B* stage for which it cannot find a use, although the *Nimbus* purchased for the Department of Commerce will be utilized in NASA's R&D program. In addition, he said, cancellation of the Hiland Command and Data Acquisition station has made surplus one antenna which cannot be used economically in the NASA program unless the Weather Bureau can find another use for it.

***Titan III* success noted . . .**

Project Definition Technique To Be Applied to Many More Programs

Services preparing implementing instructions for conversion to across-the-board application; a detailed DOD explanation

by James Trainor

DEVELOPMENT PROJECTS costing as little as $25 million, as well as those whose production costs are $100 million and above, will be subject to a Project Definition Phase (PDP), under a new directive from the Dept. of Defense.

Project Definition, which falls at the critical juncture between Advanced Development and full-scale Engineering or Operational Development, has thus far been applied to only a few selected programs. Among these are *Titan III*, *MMRBM*, *Lance* and the airborne portion of the Military Communications Satellite programs.

The effect of the directive is to convert from what until now has been a controlled experiment of a management technique to an across-the-board application.

Defense officials, although they admit that no weapon system that has gone through Project Definition has yet completed its life cycle, are enthusiastic about the efficacy of the management technique. The example most pridefully mentioned is the *Titan III* program, which underwent the full Project Definition treatment.

"We believe that the *Titan III*, on which I guess more than half the money has already been spent . . . (although it) is unlike most, and it is too early to boast, is on schedule and within the planned funding," Dr. Harold Brown, Director of Defense Research and Engineering, told a Congressional committee recently.

(Project Definition is identical to what formerly was called Program Definition. The name was changed so that the process would not be confused with the more well-known Program Packages used by DOD Comptroller Charles Hitch.)

● **All ducks in a row**—The basic rationale behind Project Definition is the belief that a weapon system should not be allowed to go into full-scale development until well-established criteria are met. The technology must be in hand, the schedule realistically defined and the costs tied to both the technology and the schedule.

Specifically, the directive (DOD Directive No. 3200.9 dated February 26, 1964) states that the "most important" objective of Project Definition is to provide an adequate basis for management decisions to proceed with, cancel or change development projects. These decisions, the directive points out, are made on a total system and total cost basis.

Other objectives of the Project Definition Phase are to:

—Establish firm and realistic specifications.

—Precisely define interfaces and responsibilities.

—Identify high-risk areas.

—Validate technical approaches.

—Establish firm and realistic schedules and cost estimates for Phase II (full-scale development), including production engineering, facilities, construction and production hardware.

—Establish schedules and cost estimates for planning purposes for the total project, including production, operation and maintenance.

In the case of contractor-conducted Project Definition, the final package is to include a firm fixed-price proposal or a fully-structured incentive proposal for Phase II.

● **Prerequisites for PDP**—Before one of the services can initiate a PDP, however, the action must be approved by DDR&E. The PDP is not, the Directive emphasizes, "a substitute for experimental tests, engineering, and analytical studies which provide the technical, economic and military bases for a decision to develop the equipment or system."

In other words, a request for initiation of a PDP will not be approved unless it appears that:

—Primarily engineering rather than experimental effort is required.

—"Building block" components and technology needed are sufficiently in hand.

—A thorough trade-off analysis has been made.

—The best technical approach has been selected.

—The mission and performance envelopes are defined and are optimized for technical feasibility and cost-effectiveness.

—The cost-effectiveness of the proposed item has been determined to be favorable in relationship to the cost-effectiveness of competing items on a DOD-wide basis.

—Cost and schedule estimates are credible and acceptable.

This information plus a current Technical Development Plan and a plan for the conduct of the Project Definition Phase, as well as pertinent back-up information to support these prerequisites, provides the basis for DDR&E approval or disapproval of the PDP proposal.

If the request is approved, the conduct of the PDP could take three different forms: Competitive Contractor, Sole Source Contractor and In-house Laboratories. The first is by far the preferred; the remaining two really cover special cases.

Under the Competitive Contractor procedure, two or more contractors would be selected from the initial group of bidders to conduct a Project Definition. These contractors would be fully compensated for their work on PDP, using fixed price contracts and avoiding any action which suggests cost sharing.

Contractors may also be compensated during the period between submission of PDP reports and the award of a definitive full-scale development contract. This is in order to retain key personnel on contractor teams and, for Competitive Contractor PDP, to preserve competition. During such a period, the firms would work on assigned tasks, such as refinement of specifications.

The Sole-Source PDP situation really applies to a system already under contract and in engineering or operational development. The purpose of the PDP, in this situation, is to define the cost, performance and schedule of a proposed modification to the weapon program. This normally would be carried out by the contractor executing the development program.

Finally, the In-House Laboratory PDP is designed for those rare occasions (such as *Sidewinder* at Naval Ordnance Test Station), where it is planned that the Phase II effort will be conducted by an in-house team.

- **What is required**—In conducting the Project Definition, the contractor is expected to make system tradeoffs to obtain, within the limits of the mission and performance envelopes, an optimum balance between total cost, schedule and operational effectiveness for the system.

In addition, a detailed PERT/Cost Program plan for Phase II is also required. The PERT/Cost plan must be in such detail that it can be put into operation and reports made against it at the initiation of the Phase II effort.

Other items which must be included in the final PDP report:

—A list of each of the end items required for operation and maintenance.

—Performance specifications for each of the end items.

—Principal objectives and features of the overall system design, including recommendations for its operational use based on operational concepts established by the department or agency.

—Required new designs and technology, if any, and a proposed test plan to demonstrate feasibility, including justification of the decision that existing designs or techniques are not applicable.

After submission of the PDP, the service involved will recommend to DDR&E in writing that full-scale development based on the results of PDP and proposals received be initiated; further exploratory or advanced development of key components be undertaken; the development effort be deferred or abandoned; Project Definition be continued; or an alternative source which has met the objectives of PDP be awarded the contract for development. On the basis of these recommendations and the PDP, DDR&E will approve or disapprove the action requested.

For projects which the services feel are of such importance that the PDP should be dispensed with, they can make such a recommendation to DDR&E in writing, fully documenting the reasons for requesting the waiver. Except in specific provisions of the PDP which are reserved to the Secretary of Defense, DDR&E has the authority to grant such waivers.

The services are required under the directive to submit their implementing instructions to DDR&E by April 26. DDR&E is also preparing more detailed guidance on the implementation of PDP. This should be available within two months. ■

Due out March 30 . . .

Air Force Manual To Bring Tighter Systems Management

A NEW AIR FORCE configuration management manual aimed at eliminating what Gen. Bernard A. Schriever calls "horrible examples" of waste in time and money is in final preparation.

A "quantum jump" in Air Force systems management capability is predicted as a result of the new AFSCM 375-1, which Schriever, commander of Air Force Systems Command, says will shorten total acquisition time by shortening decision time during the entire acquisition process. One result, according to Schriever, will be an increase in the in-commission rates of operational systems, giving "overall defense capability a significant shot in the arm."

The document, seen as meaning "a new way of life" for industry in configuration identification, control and accounting, will cover not only missiles and space systems—including one-of-a-kind—but ground command and control systems and aircraft programs. A March 30 deadline has been set to have it ready for application to the CXX cargo aircraft and other upcoming programs.

At a four-day Los Angeles Air Force-industry symposium held to work out the final draft, Air Force spokesmen called it the first official implementing procedure to conform to Defense Secretary McNamara's program-definition phase. The latter is being documented for the first time in another new manual, 375-4, for distribution Mar. 16.

- **To eliminate costly changes**—AFSCM 375-1 is an attempt to give the Air Force complete control over system configuration from conceptual through operational phases, with "configuration" defined as "the complete technical description required to fabricate, test, accept, operate, maintain and logistically support systems and equipment."

The document defines "configuration management" as "the formal set of procedural concepts by which a uniform system of configuration identification, control and accounting is established and maintained for all USAF systems/equipment and components thereof."

At the symposium, Schriever cited a number of bad management examples. Among them:

—"Three early *Atlas* squadrons had an average of 200 change orders apiece with a cost of about $15 million for the three squadrons.

—"Failure to freeze missile design in one instance resulted in 3,000 engineer change notices being submitted for one element of the automatic program checkout equipment."

- **Already in operation**—Schriever said he cited these as early mistakes. He noted that improved configuration management techniques have been a major factor in accomplishments of the *Titan II* and *Minuteman* programs.

At the same time, Schriever said, investigation of "charges of tremendous overruns" in several missile programs showed that about 90% of the so-called overrun actually was due to directive changes from higher levels or changes that were necessary but not properly accounted for in terms of dollars.

"Proper configuration accounting can certainly do a lot to put the dollars in the right pocket," he said. "The improvements we want to see in configuration management are aimed at getting better work statements and, in turn, bringing about a better overall management job. We must define our overall program in more and more specific terms as each program moves through its life cycle."

With a new, standardized procedure, the Air Force should be able to acquire new systems with better reliability in less time at lower cost, Schriever said.

Industry reaction to the draft of the new document was generally approving, but there were some reservations indicating problems in application. These included the matter of imposing the new configuration control rules on vendors who may sell only a few items to a given contractor.

A Mar. 30 deadline is set for industry to present its reactions to the new manual through the Aerospace Industries Association.

The manual will be employed on all new programs, including those currently in the definition phase, and on programs already in existence as mutually agreed. ■

In next 10 weeks . . .

MSFC Plans $10 Million in Studies

RFP's from industry anticipated in four weeks for three interplanetary mission contracts; one will be Mars lander

HUNTSVILLE, ALA.—NASA's Marshall Space Flight Center will award about $10 million in study contracts in the next 10 weeks, including further work on the Project Empire series to determine the requirements for manned interplanetary space flight missions.

Three separate contracts will be awarded in the interplanetary area, with requests for proposals from industry expected in about four weeks.

One contract will concentrate on a Mars surface operation for the first manned landing mission. It will attempt to determine what the astronauts should do when they get there as well as what instruments and power supplies will be required.

The other two awards will be an extension of the Project Empire series, which laid down the broad requirements for manned missions to Mars and Venus. One will concentrate on the mode of flight and the Earth orbital operations which will be necessary to make the flight. The other will determine the payload needed for the mission.

Among the questions the selected contractor will be expected to answer are whether artificial "g" will be needed, the type of required life-support system and what the trade-offs are between various payload weights and costs.

● **20 Contracts in FY '64**—Marshall expects to award a total of 20 study contracts by the end of this fiscal year.

The large number, in comparison to the rest of the field centers in the manned spaceflight program, stems from the fact that Marshall is the only center having a Future Projects Office devoted to the study of advanced missions.

Marshall is also currently evaluating about 12 bids from industry for a study of manned systems using electric propulsion systems. Selection of a contractor is expected within the next two months.

The firm will be limited to a Mars or Venus mission using a first generation system based on the *Saturn V* booster.

The other upcoming contracts will include research efforts in the areas of advanced manned lunar operations, Earth-orbital operations and launch vehicles.

● **Lunar trajectory research**—The effort in the lunar area will continue Martin Marietta Corp. work in compiling literature on lunar trajectories.

A new contract will also be awarded to study advanced lunar systems. It will attempt to answer the question of what should follow Project *Apollo* in terms of lunar exploration.

Marshall's broad study of Earth orbital operations will also be maintained.

This invloves the entire complex of such operations, including rendezvous, orbital assembly, transfer, rescue and launch. It also implies the storage of cryogenics and the attendant problems.

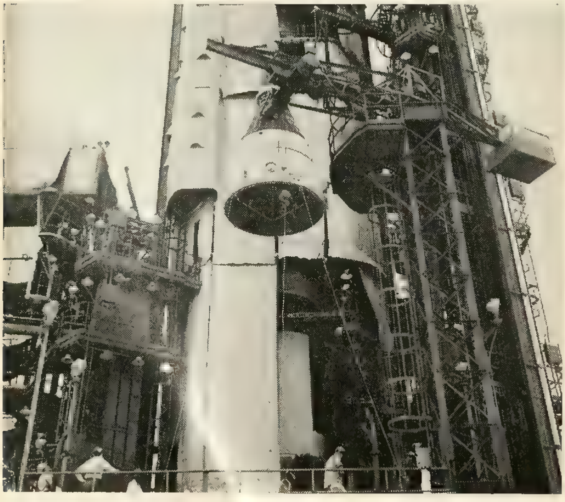
Bids will also be requested for a new study of the feasibility and requirements of a cryogenic tanker to support Earth-orbital operations.

● **Launch vehicles**—Marshall's Future Projects Office is also going to ask industry for proposals on concepts to improve the performance of the *Saturn IB* launch vehicle. This could involve solid strap-on motors on the first stage. The study will include cost, feasibility and performance estimates for each concept.

The center would also like to study modifications to the *Saturn V* booster to improve its performance. This must still be approved, however, by NASA headquarters.

In terms of vehicles that can replace the *Saturn V*, recoverable boosters are destined for intensified study because NASA now believes they may be feasible in the mid-1970's.

The center still has not decided whether it will award additional studies of the so-called Nova-class vehicles. If it does, the FY '64 studies will cover classes II and III, involving more advanced concepts than class I, which includes only current state-of-the-art technology. ■



Gemini Goes Atop Titan

McDONNELL Gemini capsule is lifted toward its first mating with the Martin Titan II that will send it on an unmanned orbital flight. Launch may be as early as last week in March from Cape Kennedy's Complex 19.

Five-year plan, 'output catalog'. . .

Two Documents Will Assist ECAC In Solving Military RFI Problems

by Michael Getler

ANNAPOLIS, MD.—Two documents now undergoing Dept. of Defense and Air Force review will play a major part in enabling the tri-service Electromagnetic Compatibility Analysis Center (ECAC) to deal with the growing cost and complexity of military radio frequency interference (RFI) problems.

One of the documents, just handed to the AF's Electronic Systems Div., currently managing the center for DOD, is ECAC's new five-year plan. This fully details the projected requirements—and funds—to cope both with problems already at hand that will still need solving and with those associated with extension of RFI solutions into other locales and advanced equipments. Specifically, the plan is known to outline the need for the same kind of environmental and spectrum signature data for European, Canadian, and Alaskan RFI profiles as is now available for the U.S. interior zone.

The center, which has been budgeted at about $3 million per year for each of the past three fiscal years, has asked for an increase in the Fiscal Year 1965 request.

The second document, currently being reviewed by the office of the Director of Defense Research and Engineering (DDR&E) and the J-6 office of the Joint Chiefs of Staff (JCS), is an ECAC "output catalog," which should be of major value for the services and their electronics contractors. The catalog will be the first one released, although an earlier attempt was made at putting one out. It will be a periodically up-dated compilation of the types of information available from ECAC and the format.

The catalog, expected to be released in about a month, will be distributed to the services; presumably their funded contractors will have access to it. Later, it is expected, firms not working under contract but who are developing or proposing new systems will also have access to ECAC data. This type of access has been inhibited to date so that a data base and RFI analysis and modeling schemes could be developed first. The extent of industry access to ECAC is one of the major items in the current DOD review. While no doubt helpful to both interests, unless properly handled it could swamp the ECAC.

The catalog will also contain abstracts of specific ECAC analysis and a listing of ECAC documents available from the Defense Documentation Center. It will not be available from DDC.

- **Misconceptions**—ECAC's ability to help the DOD and services solve their major RFI problems is almost directly related to the size of its data base. The growth of this base, particularly in the last year, has allowed the center to begin making valuable inputs to service programs.

However, ECAC's overall contribution to defense is not readily apparent for several reasons. For one, much of its work is on classified projects. For another, seasoned observers report that individual services who come to ECAC with RFI problems on their hands in some cases do not want rival services to know of them. This not only keeps ECAC quiet, but it inhibits the flow of information in an area where experienced observers say there really is still no central clearing house for the complete RFI picture on all levels.

"A lot of people think ECAC is tying all this together," reports one scientist here, "but we are not. For example, we could use a much better feed-in from the black-box equipment designers. Measured interference specs, including harmonics, at the black-box level would greatly enhance ECAC's capability; we can get these if we request them, but in many cases we don't know about them."

The reverse is also true. The massive spectrum signature and RFI library now being developed at ECAC is becoming the largest in the country and would also be of major import to manufacturers, especially its information on such things as susceptibility characteristics of receivers.

Another misconception about ECAC is that its effort is spread evenly across the RFI board, including compatibility at the black-box level, intra-systems level, near-field environment surrounding a particular equipment such as a ship or aircraft, and total system-to-environment level.

Actually, scientists here stress that ECAC's primary charter lies in the last category—the ability to relate equipments and new systems to a complete electromagnetic environment. This category is also the hardest to control, they report, since it obviously involves interservice systems as well as the enormous considerations of commercial electronic systems.

While DOD reportedly took a somewhat narrower view of the RFI problem in earlier periods, observers say it soon became apparent that a repository was needed for analysis to determine that Army, Navy and Air Force systems would work together and that civil and Federal Aviation Agency (FAA)-type data also had to be made available. Development of highly sensitive systems such as SATCOM, which could be affected by some commercial as well as military radiations, is cited as giving impetus to the increased attention paid to the broad system-to-environment approach.

- **Two files**—ECAC's data base, reports the center's technical director, J. Paul Georgi, is made up of an environmental file and a spectrum signature file. The former includes data on location of equipments, surrounding terrain, on-off and duty cycles, operation modes, elevation, azimuth, and frequencies. It also includes propagation path data between elements.

The spectrum signature file acutally is composed of two categories—a nominal characteristics file and measured spectrum signatures. The nominal characteristics file is data extracted from contractor's manuals or technical orders concerning side-bands, pulse width and repetition rate, sensitivity, gain, and polarization. The major disadvantage of this data is that generally it is supplied only at the fundamental frequency and does not contain data on harmonics and spurious emission susceptibilities. To date, ECAC has extracted data on some 1,714 military and FAA systems, including 539 transmitters, 653 receivers, and 990 antennas (some systems have common components).

To complement this file, the center has also taken detailed spectrum measurements on 134 military systems thus far. There are about nine levels of spectrum measurement; the choice depending partly upon the detail required and partly upon the ability to build upon previous measurements. ECAC measurement efforts are in large part aimed at reducing the future expense of these investigations through development of synthesis procedures for analyzing virtually any type of new equipment and its environment. Much of the measured data taken to date has been used to determine accuracy of synthesis procedures.

- **Capabilities**—The ECAC data base has grown large enough so that the center can now supply environmental profiles of the entire United States (not including Alaska), or Zone of the Interior (ZI), for all fixed-base military equipments which operate above 100 mc. The 100-mc level was the directed separation point in an effort to first isolate radars from communications equipments. Completion of the non-military, fixed, above-100-mc profile is expected by September of this year. Collection of some mobile environmental data (such as aircraft, ships, police nets and taxi fleets) has begun, with the initial data collection expected to be completed by August. The schedule for logging equipment under 100 mc is now being developed, according to ECAC.

The biggest non-military source of ECAC data is currently the FAA, and the speed with which that agency gets data to ECAC has a substantial effect on the center's capabilities. NASA also provides a large input. Other agencies from whom data is collected include the Weather Bureau, Federal Communications Commission, Coast Guard, and International Radio Advisory Commission.

In order to store, process and analyze the large volume of data required for RFI analysis, and also speed the output, ECAC last spring put a high-speed Univac 1107 digital computer into operation. The computer operates on two channels, allowing print-out while a program is being run.

Use of high-speed data processing is a key to the center's usefulness, ECAC director Col. Charles C. Woolwine told M/R. "The goal is not just to do a job for the services, but to do it fast." The center currently is known to be able to supply spectrum signature and environmental run-offs in one day, although it requires up to several days for some of the more complex requests involving design requirements or frequency assignments for new systems.

- **Stable of models**—Building upon the data base, several mathematical models have been developed as the major tool for rapid computer-based prediction of interference that would occur at any specific site and the effect of the interference on the operation of any receiving system in that same environment.

The models also are evolutionary, building upon each other to yield a system modeling capability. Basic models, which describe a class of equipment, have been completed for search radar, communications, IFF, beacon, and tracking radar. Complementing these are some 20 element models which, in effect, represent special circuitry, such as Moving Target Indicator and Fast-Time Constant components, which when added to the basic equipments would depict a specific piece of equipment. Equipment models then combine both of the first two.

In addition, the center has developed five propagation-path models, systems models which describe interference patterns of two or more equipments, and optimization models which provide fine-tuning to a system to further improve its compatibility.

Also, ECAC has developed new specialized models, such as the so-called "cull model," which, based on worst-case conditions, eliminates (using major operating parameters) all those obvious equipments which could not contribute to a specific RFI problem. As an example of the effectiveness of this, ECAC reports that in a detailed analysis of the Montgomery, Ala., Air Defense Sector (MOADS) for the military, the cull model eliminated all but 13 out of 13,000 radars in the sector which could be contributing to the problem. The MOADS project was one of the first checks on ECAC's ability to model an area and predict an environment; subsequent checks using aircraft reportedly validated the ECAC figures.

Another specialized model is the Frequency Assignment Model, which in its current form can compute interference between 25 equipments each capable of 188 different tuning positions and, in so doing, establish a frequency index and priorities. The FAM is expected to be expanded, and is now being applied to classified projects.

Other advantages of modeling are expected to come through ability to check out proposed standardizations of electronic equipments, and ability to predict equipment interactions before the equipments are even built. Growth of the data base also is expected to allow prediction of parameter sensitivity to pick out weak links earlier in design. In addition, ECAC is expected to get into studies of emissions from equipments that aren't meant to radiate.

- **Some projects**—Whereas ECAC does suffer somewhat from lack of exposure, certain of its project activities can be mentioned. In addition to the MOADS work, and a similar analysis being carried on dealing with the military's L-band radar problem in the San Diego area, the center is known to be contributing to development of ferret-type airborne and spaceborne sensors designed for listening to communications and other emissions over any corner of the Earth.

ECAC's role here is two-fold: one, it can tell a sensor designer what his system should see and report if it flies over a known RF environment in the U.S., thereby aiding test and check-out; it can also help to profile certain areas in order to allow detection of new signals. ECAC's ability to provide data in this second role is very apt to increase as electromagnetic intelligence gathering improves and is channeled into the center, and also as the major effort to record environments spreads from the U.S. into other NATO countries.

Another example of ECAC's input is found in the design of the huge SPADATS radar now being assembled at Eglin AFB, Fla. (M/R, Feb. 24, p. 44). ECAC analysis showed that the fourth harmonic of the steering frequency for the electronically scanned phased-array radar would interfere with the frequency guard band for a Navy satellite. The ECAC input was used to alter the frequency; however, the device will not be turned on until later this year to verify the fix.

ECAC, set up in early 1961, works mainly on frequency management and R&D problems of DOD and the services. Though a tri-service organization, ECAC's development and present management is an Air Force responsibility, currently handled by the System Command's Electronic Systems Div. Overall policy guidance, and project assignment, must come through the two ECAC designees in DDR&E. (Dr. James M. Bridges) and the JCS J-6 office (Rear Adm. T. A. Torgenson).

The contractor has access to ECAC data through the service procurement officer and then the service deputy at ECAC. Technical support for ECAC thus far has come from the Illinois Institute of Technology Research Institute under a series of non-profit contracts totaling $8 million to date. Eventually, the center hopes to have all military and civil service support. ■

Missiles and Rockets/MARCH 1964

ASTROLOG

Current status of U. S. missile and space programs

Missiles

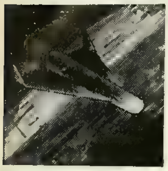
PROJECT	CONTRACTORS	DESCRIPTION	STATUS
★**A-11 MISSILE** (Air Force)	Hughes, missile and fire control	No details released; possibly advanced version of FALCON	Experimental Test at Edwards AFB; existence revealed by Pres. Johnson, Feb. 29; a "dozen" A-11 aircraft are flying
★**ALFA** (Navy) (RUR-4)	Navy, prime; frame, Avco; propulsion, Naval Propellant Plant	ASW; surface-to-underwater; weight—500 lbs.; solid motor; HE depth charge; free-flight rocket; range 900 yds.	Operational; deployed on destroyers and cruisers
★**ASROC** (Navy) (RUR-5)	Minneapolis-Honeywell, prime; Sangamo Electric, sonar; torpedo, GE; Librascope-General Precision, fire control	ASW surface-to-underwater; solid; nuclear or conventional warhead, range between 1800 yds. and 8 miles; weight: 1000 lbs.; unguided	Operational on DE, DD, DLG, & heavy cruisers; one "live" weapon fired in Pacific nuclear tests; industry competition for extended range version expected this year.
ASTOR (Navy)	Westinghouse, prime	Mark 45 ASW underwater to underwater wire-guided torpedo; nuclear or conventional; range, about 11 n. m.	In production; to be deployed on hunter-killer submarines
★**ATLAS** (Air Force)	STL, systems engineering & technical direction; GD/Astronautics, frame; GE/Burroughs/Arma, guidance; Rocketdyne, propulsion; GE/Avco, re-entry vehicle	ICBM; 5500-to-9000 mile range; liquid; nuclear; ATLAS "E" and "F" series inertial guidance; ATLAS "D" radio inertial	13 squadrons operational at 11 bases; total no. of missiles: 126; phaseout of ATLAS D's to begin in FY '65; ATLAS Standard Launch Vehicle being developed for AF space programs; 5-engine model proposed
★**BOMARC A** (Air Force)	Boeing, prime; IBM/Westinghouse, guidance; Aerojet/Marquardt, propulsion	Ramjet surface-to-air interceptor; liquid booster; 200 n. m. range; Mach 2.5; nuclear; ceiling, over 68,000	Five bases operational in northeastern U.S. to be phased out by the end of 1965; production completed; costs $20 million per year to operate system
BOMARC B (Air Force)	Boeing, prime; Gen. Precision Aerospace/Westinghouse, IBM guidance; Thiokol/Marquardt, propulsion	Ramjet, surface-to-air; solid booster; Mach 2.7; more than 400 n. m. range; nuclear	First base operational May, 1961; two more planned; production completed
★**BULLPUP** (Navy-Air Force) (AGM-12C)	Martin and Maxson Electronics Co., guidance and control and airframe; AMF, liquid engine; Naval Propellant Plant, propulsion (motor loading)	Air-to-surface; 3-6 mile range; radio-link command guidance (visual reference); BULLPUP A: conventional 250-lb. warhead; BULLPUP B: 1,000-lb warhead and a more powerful, pre-packaged liquid motor	BULLPUP A deployed with Atlantic and Pacific Fleets; operational with Air Force units; training version (ATM-12) being procured by both services
CORPORAL (Army)	Firestone, prime; Gilfillan Bros., Inc., guidance; Ryan, propulsion	Surface-to-surface; 75-n. m. range; liquid; nuclear; pre-set and command guidance	Deployed in Europe. SERGEANT replacing CORPORAL
DAVY CROCKETT (Army) (M-388)	In-house project directed by Army Weapons Command at Rock Island, Ill.	Surface to surface; solid; bazooka-launched; sub-kiloton nuclear warhead; two launchers: vehicle-mounted or carried by two men	Operational in Europe; $13 million provided in FY '64 budget; 3 per ROAD battalion; seen as defensive rather than offensive weapon to prevent overrun of Europe
ENTAC (Army)	Nord Aviation, prime	Antitank; 6600-ft. range; 37 lbs.; solid; shaped charge HE warhead; wire-guided; man-portable	Operational; Army buying from French in quantity to replace SS-10
★**AADS-70** (Army)	Hughes, Raytheon, RCA—feasibility and technical tradeoff studies	Field army ballistic missile defense system, mobile	Technical tradeoff studies being evaluated; component development expected to start this year; development cost tops HAWK/HERCULES total
FALCON (Air Force)	Hughes, prime; Hughes, guidance; Thiokol, propulsion; Lockheed Propulsion, AIM-47 propulsion	Air-to-air; 5-n. mi. range; supersonic; solid; conventional; AIM-4A, and 4E, active radar homing guidance; AIM-4B, 4-C, 4-D, and 4-F, IR homing; AIM-26 model has nuclear warhead and hybrid IR radar homing	Operational; buy-out of 4E, 4F and 26 in FY '62; AIM-47 under minimum effort development

★ Indicates changes since January, 1964, Astrolog

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
★**FLEET AIR DEFENSE MISSILE** (Navy)	No contracts announced	Surface-to-air	Will replace standardized missile and use technology from TYPHON programs; fleet defensive weapons for 1970's
GENIE (Air Force)	Douglas, prime; Aerojet-General, propulsion	Air-to-air; unguided; 6-mile range; nuclear; solid rocket; supersonic; proximity fuzing	Operational on F-101B & F-106; improved version cancelled
HAWK (Army)	Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion	Surface-to-air; 22-mile range; 100-45,000 ft. ceiling; launch wt., 1275 lbs.; solid; conventional; provides defense against medium and low-flying aircraft and cruise-type missiles	Operational; deployed in Europe, Panama, Okinawa, U.S. (13 battalions); bought by Sweden and Israel; advanced HAWK being funded at $25.9 million for R&D as antimissile weapon. NATO producing
HONEST JOHN (Army) (M-31, M-50)	Douglas/Emerson Electric, prime; Hercules, propulsion	Surface-to-surface; unguided; M-31, 12-mile range; M-50, 20-mile range; nuclear; 5900 lbs.; M-50 being deployed	Operational; deployed in Europe; to be replaced by LANCE
HOUND DOG (Air Force)	North American, prime; Autonetics, guidance; Pratt and Whitney, propulsion	Air breathing air-to-surface standoff missile; about 600 n.-mi. range; Mach 2+; turbojet nuclear B version in production; ceiling in excess of 50,000 ft.	Operational; to be launched from B-52G intercontinental bombers; stockpile expected to exceed 400
★**LACROSSE** (Army)	Martin, prime; Martin/Federal Div. ITT, guidance; Thiokol, propulsion	Surface-to-surface; mobile; command guidance; 20-mile range; solid; nuclear	Last unit deactivated November, 1963
LANCE (Army)	Ling-Temco-Vought, prime; Systron-Donner, AUTOMET guidance	A highly mobile general-purpose missile; range 3-30 miles; Automet guidance; one missile per launcher; nuclear and conventional warhead; pre-packaged storable propellants	Large-scale development; eventually will replace HONEST JOHN and LACROSSE; division support weapon; to use multi-system test equipment
LITTLE JOHN (Army)	Emerson Electric, prime; Hercules Powder, propulsion	Surface-to-surface unguided; 10-mile range; solid; nuclear; supplements medium and heavy artillery in airborne divisions and air-transportable commands	Two battalions activated in '61; each equipped with four launchers; air and helicopter transportable; may be replaced by LANCE
★**LOW ALTITUDE SUPERSONIC VEHICLE** (Air Force)	Ling-Temco-Vought, nuclear vehicle components; AEC/Marquardt, nuclear and chemical technology; Lockheed, studies of chemical version	Surface-to-surface; low-altitude; supersonic; nuclear or chemical ramjet; designed to conduct long aerial patrols at speeds up to 2000 mph	Nuclear propulsion system being developed under project PLUTO; feasibility proven by TORY reactor tests. Tory II-C tests to begin in early 1964
M72 (Army)	Hesse-Eastern Div., Flightex Fabrics, prime	Light antitank rocket; carrier tube launcher; 4.5 lbs.; range 500 yd.; earlier called LAW	Operational
MACE (Air Force)	Martin, prime; Goodyear/AC Spark Plug, guidance; Thiokol/Allison, propulsion	Air-breathing surface-to-surface; more than 650-mile range; turbojet and solid; nuclear; B model: 1200-mile range; inertial guidance	Five MACE-A and one MACE-B squadron deployed in Europe; two MACE-B squadrons on Okinawa in hard sites
MATADOR (Air Force)	Martin, prime; Air Force, guidance; Thiokol/Allison, propulsion	Air-breathing surface-to-surface; 500-mile range; speed, about 650 mph; ceiling above 35,000 ft.	Being turned over to West Germans; also deployed in Korea and on Taiwan
★**MAULER** (Army)	GD/Pomona, prime; Hughes, guidance; Lockheed, propulsion; deHavilland, IR acquisition; Raytheon, radar; Burroughs, computer; FMC, carrier vehicle	Surface-to-air; IR acquisition; solid; weight, 120 lbs.; highly mobile antiaircraft and antimissile missile; tracked vehicle; 9 per launcher rack	Development; suffering serious guidance problems. Army concentrating on initial model; postponing more advanced models
★**MOBILE MEDIUM-RANGE BALLISTIC MISSILE** (Air Force)	Development Phase: Hughes, integration, assembly and checkout; Ford Aeronutronic re-entry system; Thiokol, propulsion; Goodyear Aerospace Corp., transporter-launcher-erector; Martin-Marietta, command and control; General Precision, guidance	Two-stage, solid propellant, stellar-inertial guidance; entire system contained in one mobile vehicle; range: 300-1500 miles	Continued development of guidance, control systems; lack of deployment objective or valid military requirement has led Congress to drastically reduce program
★**MINUTEMAN** (Air Force)	STL, systems engineering and technical direction; Boeing, major contractor; Autonetics, guidance; Thiokol, propulsion first stage; Aerojet, propulsion second stage; Hercules third stage; Avco, re-entry vehicle	2nd-generation ICBM; solid; deployed in hardened and dispersed silos; 32-sec. reaction time; nuclear; 3 stages; range: over 5000 miles; guidance, all-inertial; target selected in seconds; advanced MINUTEMAN with greater range-payload and new re-entry vehicle under development	Development; over 300 now operational; 1,000 missiles through FY '65; advanced version can be fired by airborne command posts; expected operational 1965; MINUTEMAN II to be colocated with MMI; also some of the II's will replace the earlier models
NIKE-HERCULES (Army)	Western Electric, prime; Western Electric, guidance; Hercules and Thiokol, propulsion; Douglas, airframe	Surface-to-air; 75-mile range; ceiling, in excess of 150,000 ft.; solid; command guidance; Mach 3+; nuclear or conventional; antiaircraft, tactical missiles; weight, 10,000 lbs.	Over 80 batteries deployed in U.S. being turned over to National Guard; over 10 N-H batteries deployed overseas; being equipped with HIPAR, a high power acquisition radar, and anti-tactical-ballistic-missile capabilities
★**NIKE-ZEUS** (Army)	Western Electric, prime; Bell Telephone, guidance; Thiokol/Lockheed, propulsion; Douglas, airframe	Antimissile missile; 3-stage; 200-mile range; solid; nuclear; command guidance; weight, 22,800 lbs.; length, 48 ft.; diameter, 36 in.; fin span, 10 ft.	Missile to become part of NIKE-X missile "mix"; development, except as part of X, to end in FY '65; funded for $89 million in FY '64, $40 million in FY '65; ten successful intercepts. White sands tests completed
★**NIKE-X** (Army)	Western Electric, prime; Bell Telephone, guidance; Thiokol, ZEUS propulsion; Douglas, ZEUS airframe; Martin-Marietta, SPRINT missile prime; Hercules Powder Co., and Lockheed Propulsion Co., SPRINT propulsion	Most advanced portion of NIKE-ZEUS concept; uses a mix of ZEUS/SPRINT missiles and multi-function array radar (MAR)	Engineering development; funded at $334 million in FY '65 on accelerated development schedule, but deployment still deferred; tests to be conducted late this year could provide basis for deployment decision; deployment cost: $12-20 billion

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
★**PERSHING** (Army)	Martin, prime; Bendix, guidance; Thiokol, propulsion	Surface-to-surface; two-stage solid; inertial guidance; approx. 400 n. mile range; nuclear; transported on FMC XM474 tracked vehicle; to replace REDSTONE	Flight test program completed; troop firings from Ft. Wingate (N.M.) to White Sands being conducted; number of launches per unit to be increased; West Germany buying two battalions
PHOENIX (Navy)	Hughes Aircraft Co.; Rocketdyne, propulsion	Air-to-air missile for use with the TFX fighter aircraft	Development
★**POLARIS** (Navy)	Lockheed, prime; GE/MIT/Hughes, Minneapolis-Honeywell, Raytheon, guidance and fire control; Aerojet-General, Hercules, propulsion; Lockheed, re-entry vehicle; Nortronics, checkout; Autonetics/Sperry, SINS; Westinghouse, launching equipment; Vitro, systems engineering coordination and training; Systron-Donner, ignition programing	Underwater and surface-to-surface; solid; 1200-n.-m. range A-1 aboard first 5 submarines; nuclear; A-2 (1500 n.-m.) aboard submarines 6-18; A-3 (2500 n.-m.) aboard 19th through 41st; first five subs to get A-3 during FY '65; total authorized POLARIS submarine program: 41	16 subs ready for sea, 11 operational each with 16 missiles; A-2 operational; A-3 in 1964; 32 A-3 flight tests have been conducted; 20 fully successful; deployed in Atlantic and Mediterranean; Pacific servicing facilities being built; British to buy A-3 missiles from U.S. First A-3 submarine firings successful. B-3 program definition included in FY '65 budget
QUAIL (Air Force)	McDonnell, prime; Guidance Technology, Inc., guidance; GE, propulsion; Thompson Ramo Wooldridge, ECM equipment	ECM-carrying decoy; about 200 m. range; turbojet powered advanced version with 400 mile range has been flight tested	Deployed at SAC bases; carried by B-52; procurement completed FY '61
★**REDEYE** (Army)	GD/Pomona, prime; Hughes, IR seeker; Atlantic Research, propulsion	Surface-to-air; 4-foot, 22-lb. bazooka-type; IR homing guidance; solid; conventional; length, 44 in.; diameter, 2.75 in.	Initial procurement in FY '64; growth versions planned
REDSTONE (Army)	Chrysler, prime; Sperry Farragut, guidance; Rocketdyne, propulsion	Surface-to-surface; liquid; 200-mile range; inertial guidance; nuclear	Deployed in Europe; being replaced by PERSHING
REGULUS I (Navy) (SSM-N-8)	Ling-Temco-Vought, prime; Sperry, guidance; Allison, propulsion	Surface-to-surface; turbojet and solid; 500-n.-mi. range; speed, about 600 mph; ceiling, approx. 40,000 ft.; nuclear	Deployed aboard 2 cruisers; phaseout of 5 REGULUS subs started last year; missiles retrofitted with airborne guidance
SERGEANT (Army)	Sperry Utah, prime; Sperry, guidance; Thiokol, propulsion	Surface-to-surface; solid; over 75 n. mi. range; nuclear; inertial guidance; uses drag brakes; 10,000 lbs.	Production; major procurement to be completed during FY '63; replacing CORPORAL; West Germany buying and has activated one battalion
★**STANDARDIZED MISSILE** (Navy)	No contracts announced	Surface-to-air	To be standard replacement for both TERRIER & TARTAR
★**SHILLELAGH** (Army)	Ford Aeronutronic, prime; Picatinny Arsenal/Amoco Chemicals Corp., propulsion; Aeronutronic, guidance	Surface-to-surface; lightweight; vehicle-mounted for use against field fortifications, armor and close-in support of troops	Initial procurement in FY '65; to use multi-system test equipment; engineering development stage began in FY '64; to be installed on Gen. Sheridan assault vehicle
★**SHRIKE** (Navy) (AGM-45A)	NOTS-China Lake, prime; Texas Instruments, guidance and control; Rocketdyne (McGregor), propulsion	Air-to-surface; anti-radar; guidance, passive radar homing; solid motor; formerly ARM	Operational; armament for Navy and Air Force Tactical aircraft
★**SIDEWINDER** (Navy-Air Force) (AIM-90)	NOTS, technical direction; Philco, guidance; Naval Ammunition Depot, McAllister, motor loading; Rocketdyne (McGregor) propellant	Air-to-air; IR guidance; more than 2 m. range; conventional	1A deployed with Navy and Air Force; 1-C version being procured as replacement for 1-A; NATO-built version now in production
★**SPARROW III** (Navy) (AIM-7E)	Raytheon, prime; Raytheon, airframe, control, guidance; Aerojet-General, & NAA (McGregor) propulsion McDonnell & Benrus Watch Co., launcher	Air-to-air 5-8 mile range; Mach 2.5-3; ceiling, over 50,000 ft.; semi-active, CW homing, guidance; solid; conventional	Earlier models operational with carrier aircraft; SPARROW III B-6B prime armament for Phantom II (F-4B) & other high-performance interceptors
SPRINT (Army)	Martin-Orlando, prime; Hercules Powder and Lockheed Propulsion Co., propulsion; Bell Telephone Laboratories, guidance	High-acceleration missile for low-altitude interception of ballistic missiles; to be part of the missile mix in a NIKE-X battery	Development
★**SUBROC** (Navy)	Naval Ordnance Laboratory, technical direction; Goodyear, prime; Gen. Precision/Aerospace, guidance; Thiokol, propulsion; Librascope/General Precision, fire control	Underwater-air-underwater antisubmarine missile-depth bomb; 25-30 mile range; solid; nuclear	Production; scheduled for installation in Thresher class subs; will be operational this year
SS-10 (Army)	Nord Aviation, prime; GE, U.S. licensee	Surface-to-surface; primarily antitank; 1600-yards range; 33 lbs solid; wire guided; conventional	Operational with U.S., French and other NATO and Western units; battle-tested in North Africa; U.S. replacing with ENTAC
SS-11 (Army)	Nord Aviation, prime	Surface-to-surface; antitank; also helicopter-to-surface; 3800-yard range; 63 lbs; wire guided; conventional	Operational, to be used with airborne units and Army helicopters
TALOS (Navy)	Vitro, systems engineering; Bendix, prime; Bendix, McDonnell, Allegany Ballistics Lab., propulsion; Sperry, guidance; GE, launching gear	Ship-to-air; 65-mile range; solid and ramjet; Mach 2.5; nuclear; radar beam riding/semi-active homing guidance	Operational aboard cruisers Galveston, Oklahoma City and three heavy cruisers; Long Beach, nuclear-powered cruiser, has advanced TALOS
★**TARTAR** (Navy) (RIM-24B)	Vitro, systems coordination engineering; Applied Physics Lab, design and development; GD/Pomona, assembly and test; Raytheon, guidance; Aerojet-General, propulsion (motor loading); Sperry Farragut Fuze (target detection devise)	Ship-to-air; 10-mile range; Mach 2; beam-riding guidance; solid dual-thrust motor; conventional	Operational; installed aboard 15 guided missile destroyers and cruisers equipped with TALOS; "get well" program progressing satisfactorily
★**TERRIER** (Navy)	Vitro, systems engineering; GD/Pomona, prime; GD/Pomona, guidance section; Sperry, radar; ABL, propulsion; Northern Ordnance, launching gear	Ship-to-air; 10-mile range; Mach 2.5; 27 feet long; solid, conventional	Operational aboard two attack carriers, 6 cruisers, and 12 missile frigates; "get well" program progressing satisfactorily

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
TITAN I (Air Force)	STL, systems engineering & technical direction; Martin, prime; Bell/Sperry, guidance; Aerojet-General, propulsion; Avco, re-entry vehicle	ICBM; 5000-mile range, LOX/RP-1 fueled; 90 ft. long; 2 stages	Operational; 54 missiles at 5 bases
★**TITAN II** (Air Force)	STL, system engineering and technical direction; Martin, prime; AC Spark Plug, guidance; Aerojet-General, propulsion; GE, re-entry vehicle	ICBM; over 5000-mile range; N_2O_4 & Aerozine-50 storable fuels; 115 ft. long; 2 stages; greatest payload & range of any U.S. ICBM; basic core vehicle for TITAN III	All 54 missiles operational: One squadron (18 missiles) operational at Davis-Monthan AFB; one (18 missiles) at McConnell AFB and one (18 missiles) at Little Rock AFB
TOW (Army)	Hughes, prime	Tube-launched, optically tracked, wire guided, HE warhead	Follow-on to ENTAC
★**TYPHON** (Navy)	Bendix, GD/Pomona, missile and missile electronics; Westinghouse, weapons direction system and radar; McDonnell/Allegany Ballistics Laboratory, propulsion; Northern Ordnance, launching gear	Medium and long range seagoing anti-aircraft and antimissile missiles with offensive capability against surface ships and shore targets	Program cancelled; tests of radar on the Norton Sound will be continued
ZUNI (Navy)	Naval Ordnance Test Station, prime; Hunter-Douglas, propulsion	5-inch, air-to-surface; solid; unguided; 5 n.-mi. range; conventional	Operational; designed for use on jet fighter and attack aircraft



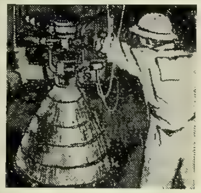
Satellites and Spacecraft

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
★**ADVANCED TECHNOLOGY SATELLITE** (NASA)	Hughes, prime	Five-satellite program to test communication and meteorological equipment at medium and synchronous orbit; 600 lbs. weight; launch vehicle: ATLAS-AGENA	New program in the FY '65 budget; flights, scheduled for 1966-68
★**ANNA** (NASA)	Allied Physics Lab, prime; AF Cambridge Research Laboratories/Edgerton, Germeshausen & Grier flash tube experiment; Army Engineers/ITT, SECOR (developed by Cubic Corp.)	Geodetic satellite; 600-mi. orbit; 36-in. aluminum sphere (with solar cell belt, 48 in.); weighs 355 lbs.; boosted by DELTA; SECOR: 9 x 11 x 14 ins., Wt. 40 lbs.; can be carried piggyback on variety of boosters	Development; first launch failed May 10; second launch successful in November. Program now under NASA management. NASA to launch one satellite per year beginning in 1964. SECOR successfully orbited in January by DOD
★**APOLLO** (NASA)	North American, Command & Mission Modules, systems integration; Grumman Lunar Excursion Module (LEM); MIT, guidance development; Collins Radio, telecommunications; Minneapolis-Honeywell, stabilization & control; AiResearch, environmental control; Northrop Ventura, parachute recovery; Lockheed Propulsion Co., escape tower rocket; Marquardt, reaction controls; IBM, realtime computer complex; Westinghouse, power conversion equipment	Three-man spacecraft for Earth-orbital, lunar-orbital and lunar-landing missions. Boosters: SATURN I and SATURN IB for Earth orbits; SATURN V for lunar rendezvous; 3-modular spacecraft: command module, 5 tons; service module, 23 tons; lunar excursion module, 12.75 tons; total weight: 85,000 lbs.	Unmanned Earth oribtal shots scheduled 1964-65; lunar orbits 1968; lunar landing by 1970; first manned orbital flight fourth quarter 1966
AEROSPACE PLANE (AF-NASA)	No contracts announced	Manned, hypersonic spacecraft capable of Earth-to-orbit-and-return; turbofan, Mach 0-3; ramjet, Mach 3-8 or 10 (oxygen collected and liquefied during this cycle); Mach 8-10 orbital speeds, LH_2-LOX rocket	Joint NASA-AF research program approved. NASA funding $4 million in FY '64
★**ASSET** (Air Force)	McDonnell Aircraft Corp., prime; Minneapolis-Honeywell, guidance	Aerothermodynamic/elastic Structural Systems Environmental Tests for various materials combinations during re-entry; two versions planned, 1100 lbs. (4) and 1200 lbs. (2). Length: 68.7 ins.; span: 58.9 in.	Development; program to be expanded to study different shapes, materials, etc. One AMR shot successful although vehicle not recovered; second shot planned for March
★**BIOS** (NASA)	GE, prime	1,000-lb. recoverable capsules with primates aboard; capable of orbital flights up to 30 days. Launch Vehicle THRUST-AUGMENTED DELTA	Six flight models to be built. First flight in December, 1965. Others to follow at three-month intervals; first experiments selected in February
★**MILITARY COMMUNICATIONS SATELLITE** (AF-DCA-Army) (Program 369)	Philco-TRW-STL have completed studies	Multiple-launch, random, active repeater ComSat; four series of 6-8 satellites in 6,000 naut. mile polar orbits placed in planes 45° apart; weight, about 100 lbs.; ATLAS-AGENA booster	Status unclear; program definition completed; decision on development delayed while DOD determines suitability of Comsat Corp. system; synchronous system shelved
★**COMSAT CORP. SATELLITE PROGRAM**	Proposals submitted by: Hughes, Philco, TRW with ITT, and AT & T and RCA as joint contractors	Experimental synchronous satellite to be launched in 1965	6-month contracts to be let for design and engineering on system; initial operational capability expected in 1966
DISCOVERER (Air Force)	Lockheed, prime; GE, re-entry vehicle	THOR-AGENA and ATLAS-AGENA launchings of stabilized satellites; main purpose is to test techniques and components for military space systems	Program life extended; all data on launchings classified as part of new DOD information policy; testing of AGENA D assigned to DISCOVERER program

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
★**ECHO** (NASA)	Langley Research Center, prime	ECHO I: 135 ft. inflatable sphere in 700- to 805-mile orbit; passive communication satellite. THOR for ballistic tests; THOR-AGENA for orbital	ECHO I in orbit since Aug. 12, 1960; two ballistic shots in 1962 unsuccessful. ECHO I. launched from Vandenberg Jan. 27; U.S.-U.S.S.R. conducting series of cooperative experiments
★**GEMINI** (NASA)	McDonnell, prime; Rocketdyne, spacecraft propulsion; General Electric, fuel cell; IBM, guidance system integration and computer; Minneapolis-Honeywell, guidance; Westinghouse, rendezvous radar; AiResearch, environment	Bigger and heavier MERCURY capsule; to carry two men for periods up to two weeks, TITAN II to be used as booster. ATLAS-launched AGENA will be used for rendezvous missions. 15 spacecraft will be produced	Development; will be used to determine feasibility of rendezvous for lunar mission; first unmanned flight, April, 1964. Manned and rendesvous flights, 1964-65; AF participating in program
INTERPLANETARY MONITORING PLATFORM (NASA)	Goddard Space Flight Center, prime; Martin Co. developing nuclear power unit	125-lb. satellite launched into deep-space orbit with an apogee of 172,000 miles. It will measure radiation and solar flares in advance of Project APOLLO hazard. Launched by DELTA booster from AMR	Program calls for eight satellites. Launches will begin early 1964. Later flights will use a nuclear power unit as replacement for solar cells
★**ISIS** (Canada-US)	Canada Defense Research Board, Satellite; NASA, Launch Vehicle	Three-satellite program, follow-on to ALOUETTE, to continue ionospheric studies	Design of ISIS A to begin this year with launch in 1967; B & C to be launched in 1968, 1969
★**LUNAR ORBITER PHOTO CRAFT** (NASA)	Boeing, prime; RCA, power and communications; Eastman Kodak, cameras.	800-lb. spacecraft launched by ATLAS-AGENA will orbit Moon taking pictures of lunar surface; radioactive and geodetic measurements will also be taken	Ten flights scheduled beginning in 1966
LUNAR LOGISTICS VEHICLE (NASA)	None	Spacecraft to carry support payloads to the Moon. Two designs under study, LEM Truck and logistics spacecraft with 25,000 to 30,000-lb. payload	Program decision expected 1964. No funding expected until FY '66; program would cost about $1 billion
★**MANNED ORBITING LAB** (AF)	Study contracts awarded to Douglas, GE, and Martin on the ORBITING SPACE STATION (OSS)	Two-man spacecraft to establish military usefulness of man in space; booster, TITAN III; GEMINI X capsule atop 10 ft.-dia, 20 ft.-long canister lab; total weight about 25,000 lbs.; orbit below 350 mi.; flights of 30 days in shirtsleeve environment planned	Pre-program definition. Unmanned GEMINI launch early 1966, manned late; unmanned canister launch late 1967, manned first half 1968. Rendezvous capability possible later
★**ORBITING RESEARCH STATION**	Extended APOLLO spacecraft, Manned Orbiting Research Laboratory and a Large Orbiting Research Laboratory under study	Manned space station for testing components and techniques in the space environment	Decision not expected for several years
★**MARINER** (NASA)	JPL, prime	550-lb. unmanned spacecraft for early interplanetary missions to vicinity of Mars and Venus; boosted by ATLAS-AGENA B; 1000-lb. MARINER B also under development	Twelve shots planned. First scheduled Venus fly-by August, 1962, unsuccessful after booster failure; second passed within 21,594 mi. of Venus Dec. 14; two Mars fly-by missions planned in late 1964 and one in 1966
MDS (NASA)	Fairchild Stratos, prime	3400-lb. meteoroid detection satellite employing two 50 x 15 ft. extendable detector wings; Earth orbit, 300 to 800 miles; booster SATURN 1	Development; will measure size, energy and frequency of meteoroids to evaluate hazards of impact with manned spacecraft; first launch scheduled for third quarter 1964. Two will be orbited
MERCURY (NASA)	McDonnell, capsule	First U.S. manned satellite; 4000 lbs. + (capsule including escape rocket); boosters: ATLAS and REDSTONE	First manned orbital flight Feb. 20, 1962, by Lt. Col. John Glenn, USMC. 2nd, Cmdr. Scott Carpenter, May, 1962; six-orbit flight by Walter Schirra, Oct. 3, 1962; modified MERCURY made 22-orbit flight with L. Gordon Cooper on May 15. Program now completed
★**MIDAS, PROGRAM 239A** (Air Force)	Lockheed, prime; Aerojet, IR detector system	Early-warning satellite; detect ICBM launchings by IR; two flights conducted in 1963 detected solid and liquid missiles	Development; No decision on deployment reportedly competing with over the horizon radar
★**NIMBUS** (NASA)	Goddard Space Flight Center, prime; GE, integration and testing; RCA, videcon cameras	2nd-generation weather satellite; Earth-stabilized polar orbiting; 750 lbs.; TV cameras and IR scanners in payload; THOR-AGENA B booster	First launching scheduled for 1st Qtr 1964; second, six months later; two R&D satellites to be funded in FY '65; uses APT system
★**OAO** (NASA)	Grumman, prime; Westinghouse, ground station components; GE, stabilization and control; Kollsman, star trackers; IBM, data processor and storage; Hughes and Avco, communications equipment	3500-lb. orbiting astronomical satellite to study ultraviolet spectrum from approximately 1200Å-4000Å; four major experiments selected; one piggyback; booster, ATLAS-AGENA D	Three flights beginning in late 1965; three more spacecraft to be contracted for this year

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
OGO (NASA)	Space Technology Laboratories, prime	1000-lb. satellites with instruments for geophysical measurements; polar (POGO) and eccentric (EGO) shots planned; can carry 50 experiments; ATLAS-AGENA B, THOR-AGENA D, CENTAUR boosters	First flight scheduled in 1964; 19 experiments planned for first shot; five other flights planned
★**OSO** (NASA)	Ball Brothers, prime	OSO I, 458-lb. orbiting solar observatory; OSO II, 535 lbs.; DELTA and ATLAS-AGENA boosters, S-16 early version; S-17 and S-57 advanced versions	First flight March 7, 1962, highly successful; first flight for S-17 planned for first quarter 1964; five more flights planned
★**PIONEER** (NASA)	STL	136-lb. spin-stabilized solar probe; augmented DELATA launch vehicle; cylindrical; covered with 10,000 solar cells; 4 outrigger booms for stabilization; 5 experiments, 60-to-90-million-mi. communication capability	Seven launches in program; early 1965 launch schedule set; orbits range from .8 to 1.2 au for 6-mo. lifetime
★**RANGER** (NASA)	JPL, prime; Aeronutronic, capsule; Hercules, retrorocket; Northrop, support contractor; RCA, TV system	300-lb. instrument capsule with seismometer rough landed on Moon; before impact, TV camera takes pictures of lunar surface; ATLAS-AGENA B booster	RANGER VI launch Jan. 30; TV system failed; five-man panel reviewing program; total of nine spacecraft planned; RANGER VII postponed indefinitely
★**RELAY** (NASA)	STL, project coordination and systems planning; RCA, prime	172-lb., spin-stabilized, wide-band, 700-4000-mile orbit active repeater experimental communications satellite. DELTA booster	Britain, France, Brazil and Germany building ground stations; first launch, Dec. 13, 1962; RELAY II launched Jan. 21, 1964
★**SATELLITE INSPECTOR (PROGRAM 706)** (Air Force)	RCA, prime; Hughes, detection equipment	Satellite inspection system consisting of a spacecraft capable of co-orbital inspection of non-cooperative satellites	Conceptual preliminary design studies under way; early GEMINI flights expected to provide important inputs; $2 million in FY '65
SAMOS (Air Force)	Lockheed, prime; photo intelligence equipment, Eastman Kodak; capsules, GE; parachute and guidance recovery equipment, Avco & Northrop Ventura	Reconnaissance satellite; formerly SENTRY; R&D model weighs 4100 lbs. with E-5 capsule (3000 with E-6); ATLAS-AGENA booster; 100-300-mile circular polar orbit	Operational; advanced SAMOS under development; FERRET version used for electronic intelligence and communications eavesdropping
SERT (NASA)	RCA, prime	Spinning satellite carrying two electric-propulsion engines for environmental tests	Two and possibly three flights planned First, third quarter, 1964
SURVEYOR (NASA)	Hughes, prime; Martin, SNAP device	2100-lb. spacecraft for soft-landing 100-300 lb. instruments on Moon; ATLAS-CENTAUR booster; SNAP nuclear generator optional	First Moon flights early 1965; seven soft-landing vehicles planned
★**SYNCOM** (NASA)	Hughes, prime	24-hr. orbit instantaneous narrow band, active repeater communications satellite. DELTA booster; 28 inches in dia. and will weigh about 55 lbs.; capable of accommodating one full duplex radio telephone channel	First launch failed, Feb. 14, 1963; satellite believed to be in orbit but contact lost. SYNCOM II launched July 26, 1963, completely successful. 500-lb. advanced SYNCOM cancelled
★**SMS** (Synchronous Meteorological Satellite) (NASA)	Republic, Astro-Electronics of RCA, Hughes, study contracts	24-hour weather satellite, Earth-stabilized; TV cameras with variable focus; may use SNAP-50 for power; booster may be ATLAS-AGENA or CENTAUR	Studies to continue; development funds not included in FY '65 budget
TELSTAR (AT&T-NASA)	BTL, management for AT&T	170-lb., active repeater, experimental industry communication satellite; DELTA booster	Development; first launch July 10, 1962, highly successful; second launch May 7, 1963, also successful
TIROS (NASA-Wea. Bu.)	RCA, prime	285-lb. meteorological satellite; TV pictures of cloud cover; IR sensors to gather heat balance data; one TIROS to be tested for effectiveness in highly elliptical orbit (3000-mi. apogee)	R&D; eight satellites launched; all successful. Next launch summer, 1964. Seven more added to program (4 R&D NASA, 3 operational, Weather Bureau)
★**TRANSIT** (Navy)	Applied Physics Laboratory, prime; Martin, SNAP device; Westinghouse, shipboard satellite signal receivers	Navigational satellite; R&D model over 250 lbs.; operational, 50-100 lbs.; operational system: 4 satellites in random, near-circular 600-mi. orbits; SNAP nuclear generator; SCOUT booster	Operational system in process of being established for use by POLARIS subs; two nuclear-powered (Snap 9A) satellites launched in 1963

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
★**VELA HOTEL** (ARPA)	STL, prime; Los Alamos Scientific Lab/Aerospace, payload	20-sided, 485-lb. satellite for detection of nuclear explosions in space; 50,000-n.-mi. orbit; booster, ATLAS-AGENA; launched in pairs	First pair successfully launched in October; 1963; remaining four pairs being modified to avoid duplicating data
★**VOYAGER** (NASA)	Study contracts, Avco Corp. & GE	Unmanned MARINER follow-on spacecraft to orbit Mars and Venus and to eject a capsule to the surface	Development funds not included in FY '65 budget. Launches in 1967-70's period. Spacecraft of 6000 lbs. to be launched by three-stage SATURN 1B or SATURN V
★**X-15** (NASA-AF-Navy)	North American, prime; Thiokol, propulsion; Sperry Gyroscope, inertial flight data system; Minneapolis-Honeywell, adaptive flight control electronics	Manned rocket plane; capable of 4000-mph plus flight at edge of space; single rocket engine develops 57,000 lbs. thrust	Powered flights in progress; unofficial records set: altitude 354,200 ft. and speed (4104 mph); hypersonic propulsion research program should run through 1968; over 100 flights have been made; ramjet (X-15A2) program approval expected soon



Space Vehicles

★**AGENA D** (Air Force)	Lockheed, prime; Minneapolis-Honeywell, guidance; Bell, propulsion	1700-lb. upper stage; all-inertial guidance; re-start capability	Used in DISCOVERER, SAMOS and other military programs as well as a variety of NASA programs; ATLAS, THOR boosters
★**BLUE SCOUT** (Air Force)	Aeronutronic, prime; Ling-Temco-Vought, Inc., frame; Minneapolis-Honeywell, guidance; Aerojet/Hercules, Thiokol, propulsion	4-stage vehicle; payload cap., 345 lbs. (100-n.m.) orbit, 80 lbs. probe (1610 mi.); range, over 6000 mi. vert. distance	Operational; based on NASA's SCOUT; space probe and small (150-lb.) satellite launch vehicle; also AF's Hyper-Environmental Test System
★**CENTAUR** (NASA)	Lewis, Program Management; GD/Astronautics, prime; Pratt & Whitney, propulsion; Minneapolis-Honeywell, guidance	High-energy upper stage using a pair of RL-10 LOX/liquid hydrogen engines; 30,000 lbs. total thrust, ATLAS D booster, capable of orbiting 8500 lbs.; 2300 lbs. to escape; 1300 lbs. on planetary flights	Development; first test flight failed; 2nd launch November 27, 1963, highly successful
★**DELTA** (NASA)	Douglas, prime; Bell Telephone Labs, guidance; Rocketdyne/Aerojet/ABL, propulsion	Successor to THOR-ABLE; upper stage guidance; 3-stage vehicle; 800-lb. payload capability in 100-n.-mile orbit; THRUST-AUGMENTED DELTA payload capability: 1500+ lbs. in 100 n.m. orbit; THOR missile comprises first stage	Launch vehicle for TIROS-ECHO; being used for other satellites and one deep space probe; 26 previously on order augmented by AF order for 21 more for NASA; THRUST-AUGMENTED DELTA with 3 solid motor strap-ons also being used
LITTLE JOE II (NASA)	General Dynamics/Convair, prime	Solid-propelled vehicle with thrust of 800,000 lbs.; launch vehicle for APOLLO suborbital flights	First launch Aug. 28, 1963, successful; six vehicles ordered thus far
NOVA (NASA)	Martin, study	Capability of NOVA under study; no firm concept but should offer significant improvement over C-5 (20-30 million lbs. 1st-stage thrust or nuclear upper stage)	Study to determine characteristics; operational target date post-1970 time period
★**ORION** (Air Force)	General Atomic	Space booster propelled by series of atomic explosions to lift over 1000 tons into orbit	Studies; no military requirement; NASA reportedly interested in concept
ROVER (NASA) (AEC)	Los Alamos Scientific Labs, ROVER Prime; Aerojet, NERVA prime; Westinghouse, propulsion	First nuclear rocket: tests of KIWI, prototype of NERVA engine, under way	Kiwi tests to be completed this year. Development of Phoebus reactor initiated. No flight test program funded at present
★**SATURN I** (NASA)	Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler Corp.; S-IV, Douglas	2-stage vehicle for early boilerplate tests of APOLLO. 1st stage: 8 Rocketdyne H-1 engines; 2nd stage: 6 Pratt & Whitney RL10-A3 engines; 22,000 lbs. into 345-mi. orbit	Four flight tests of 1st stage successful; all flights with inert upper stage; first flight with live upper stages successfully launched Jan. 27 putting 37,700 lbs. in low earth orbit; SA-6 delivered to Cape Feb. 19
★**SATURN I-B** (NASA)	Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler; S-IVB stage, Douglas	S-1: 8 H-1 engines; S-IVB: 1 J-2 engine; payload capability, 32,000 lbs. in 345-mi. orbit	Development; first flight 1965; boost APOLLO spacecraft biolerplate models, including lunar landing vehicle; advanced version able to orbit 30 tons under consideration
SATURN V (Advanced Saturn) (NASA)	Systems engineering, assembly and guidance, Marshall Center; S-IC, Boeing; S-II, North American; S-IVB, Douglas; F-1, North American; J-2, North American	S-IC: 5 F-1 engines; S-II: 5 J-2 engines; S-IVB: J-2 engine; 120-ton payload in 345-mile orbit; 43 tons to escape velocity; 30 tons for planetary missions	R&D; first flight scheduled for 1966; prime booster for APOLLO missions; may also be used to boost orbiting space station
SCOUT (NASA)	L-T-V Astronautics, prime; Minneapolis-Honeywell, guidance; Aerojet-General/Hercules/Thiokol/ABL, propulsion	Solid four-stage satellite launcher; 300-lb. payload in 345-n.-mi. orbit	Operational payload being increased to 300 lbs.; NASA has ordered 23 more boosters
★**TITAN III** (Air Force) (Program 624A1)	Martin, systems integration; United Technology, large solid boosters; Martin, TITAN II vehicle; Aerojet, liquid engines; Martin, standardized upper stage; AC Spark Plug, guidance	Quick-reaction vehicle for military space missions; will be used to boost MOL/GEMINI B; 1st stage, two 120-in. solid motors; 2nd stage, TITAN II (storable propellants); 3rd stage, standardized vehicle to be developed; modified TITAN II guidance	Development; first flight late '64 (T-IIIA); Jan. '65 (T-IIIC); 17 development flights planned: 5 TITAN II core vehicles (A version), 12 full TITAN III's (C version); operational in 1965; 120-in. solid fired successfully July 20, 1963

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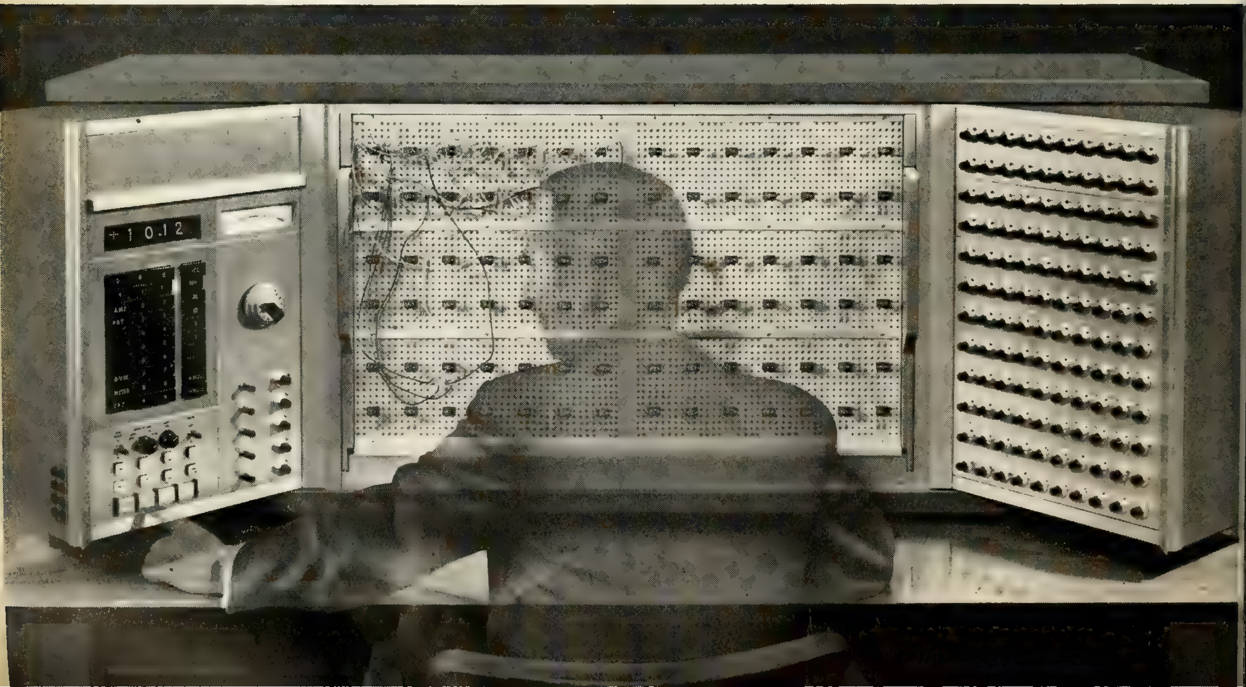

Technical Countdown

MATERIALS

Ultra-Pure Titanium Available

Titanium in the form of wire, rod or foil—with less than 0.01% total solid and gaseous impurities—is being marketed by MRC Mfg. Corp., Orangeburg, N.Y. The high purity is achieved by re-processing the highest grade of iodide titanium through electron beam zone refining. The ultra-pure element is expected to find uses in thin-film capacitors and other special electronic devices.

Fuel Cell Converts to Oxygen Detector

A fuel cell developed by Westinghouse Research Labs turns out to be one of the fastest and most sensitive oxygen detectors known, by eliminating the oxygen feed. The hydrogen-oxygen fuel cell then functions as a detector with a response so quick it can continuously pinpoint the changes in oxygen content of air during human breathing. The unit can also measure oxygen contamination in ultra-pure gases down to one part per million. The "fuel cell" detector is a zirconium-calcium oxide tube about 8 in. long and ⅛ in. across. The oxide changes from an insulator to a conductor at high temperatures. Oxygen ions moving through the material transfer from one electrode to another creating a small electric charge. Measurement of this voltage gives a direct reading of the amount of oxygen present.

Process Makes Aluminum Abrasion Resistant

A new method that makes the surface of aluminum more abrasion resistant than case-hardened steel in now in commercial use at General Magnaplate. The process also seals the aluminum surface against corrosion with Teflon, and improves the dielectric properties. One-day seminars are being offered by General Magnaplate on design properties and applications may be obtained on letterhead from Mr. Charles Covino, President, General Magnaplate Corp., Belleville, N.J.

New Atomic Energy Levels Discovered

New atomic energy levels in 12 substances including all the rare gases have been discovered by National Bureau of Standards scientists using two recently developed research techniques. The methods use previously unavailable sources of photons and electrons in the intermediate energy range from about 10 to 1,000 electron volts. The photon studies use the very-short-wavelength ultraviolet light extracted from the Bureau's 180-million-electron-volt synchrotron. The electron studies are made with a special NBS-designed spectrometer.

Vacuum Journal Published

The first issue of the Journal of the American Vacuum Society will be published in September. The publication will support vacuum research in electronics, thin films. metallurgy, space sciences, physics, processing and testing of materials and scientific instruments. The Journal will be a bi-monthly, and information may be obtained from the American Institute of Physics, 335 East 45th St., New York, N.Y. 10017.

Polymer Vacuum Data Revised

A recent investigation into the thermal stability of coordination polymers in vacuum show that their decomposition temperatures are directly related to the atomic numbers of the coordinated metals. This finding by National Bureau of Standards experts working with George Washington University may lead to predicting the thermal behavior of coordinated systems when only a minimum of experimental data is available. The study covered the metal complexes of 8-hydroxyquinoline produced by reacting bis(8-hydroxy-5-quinolyl) methane with first row transition metals such as manganese, cobalt, nickel, copper and zinc. The work was conducted in a 10^{-3} mm Hg vacuum and the results contradicted previous data gathered in air.

ELECTRONICS

Laser Range May Increase by 200%

A modulation technique developed by engineers at Sylvania Electronic Systems may increase the range of laser space communications systems by 200%. Linearly polarized light is alternately changed to circularly polarized light after passage through a Pockels cell to which an alternating modulation voltage has been applied. At the receiver, according to Sylvania engineers, right and left circularly polarized light beams are converted to orthogonal linearly polarized light upon passage through a quarterwave plate. Continuing through a Wollaston prism and separate photocell detectors, the outputs are fed into a difference amplifier and then demodulated. System performance is "substantially greater" than with intensity modulated systems because of improvements in the signal-to-noise ratio.

SINS For British From NAA

The Autonetics Div. of North American Aviation will produce the Ship's Inertial Navigation Systems (SINS) for the United Kingdom's *Polaris* subs under a series of contracts from the Navy's BuWeps. Autonetics will produce 11 marine inertial navigation systems. The total procurement will run to about $8 million. SINS is a combination of precision gyros, accelerometers and a computer that measures and remembers a ship's movements in all directions—providing continuous information on position, velocity and true North.

PROPULSION

Students Design, Build Rocket Engine

Using a stationary rocket model, designed several years ago by Rohm & Haas Corp. at Huntsville, Ala., as a model. the staff and students of the Illinois Institute of Technology have designed and built a liquid rocket engine. The IIT unit differs from the Rohm and Haas model in that it can fire continuously and yield test information on thrust, fuel burning rates and the effects of nozzle design and other criteria. The project was partially supported by the National Science Foundation. The operating engine will be used as an undergraduate teaching aid.

KOPAL
PHYSICS and ASTRONOMY of the MOON
Psychophysiological Aspects of SPACE FLIGHT
OXFORD
QUANT
MECHAN
DIRA
GODDARD
ROCKET DEVELOPMENT
TRAITÉ DE MÉCANIQUE CÉLESTE
MAXWELL
ELECTRICITY AND MAGNETISM
DOVER
NEWTON
PHILOSOPHIAE NATURALIS PRINCIPIA MATHEMATICA
KREISBEWEGUNGEN DER WELTKÖRPER
COPERNICUS

Stairway to the Moon

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BELL SYSTEM

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Promising Array Developed, Successfully Tested, then Dropped

by Charles D. LaFond

DEVELOPMENT of a practical, low-cost, multiple-beam cylindrical scanning array by Radiation Systems, Inc., would seem to be the kind of advance that would be a readily salable item.

This has not proved to be the case.

Conceived by the small Alexandria, Va., firm and supported in part by the Air Force, it was developed through the prototype stage in several hardware forms, tested successfully and dropped.

The Navy, Army, NASA, the Federal Aviation Agency and the Communications Satellite Corp. have all expressed high interest—but no support. The Naval Research Laboratories thought it a fine idea, then decided to develop a system for its own purposes as an in-house project under the direction of Dr. Arthur Marsten.

NRL is building a 16-element array for a classified application. "The RSI idea is ingenious," Dr. Marsten told M/R. "It is the only device of its kind capable of 360-degree azimuth scanning." The system, he pointed out, employs a Butler matrix and is actually very complex. NRL is particularly interested in testing the array for radar use in the microwave region, he disclosed.

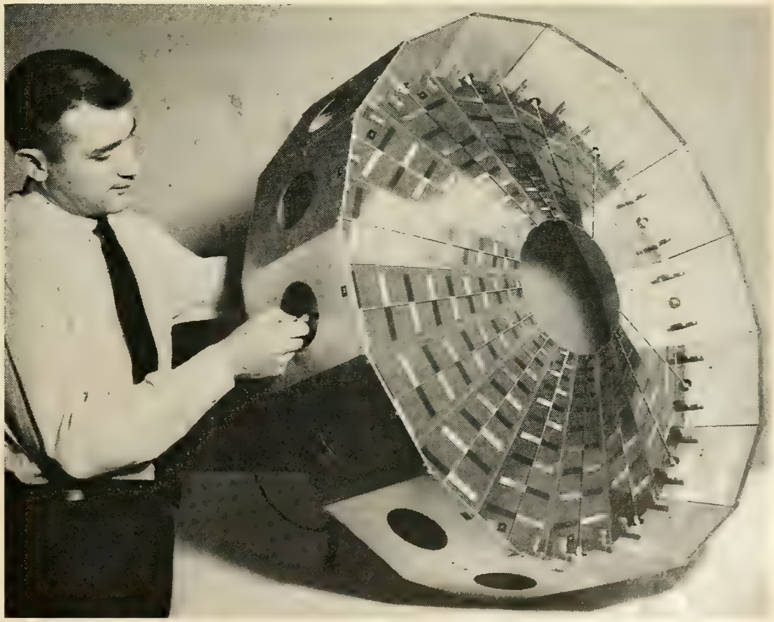
Julius Kaiser of the Antenna System Branch at Goddard Space Flight Center told M/R that he expected NASA might be very interested in the RSI arrays in the near future. Personally, he disclosed, he is interested in the approach for providing hemispheric coverage in an interferometric tracking application. The array, he pointed out, is capable of providing uniform omnidirectional coverage in one plane at high frequencies—something not achievable with other existing antennas.

Besides its ability to provide 360-degree azimuth coverage, the array can scan with its multiple beams individually or simultaneously, and has a potential for use in communications, radar and electronic warfare (ECM, ECCM).

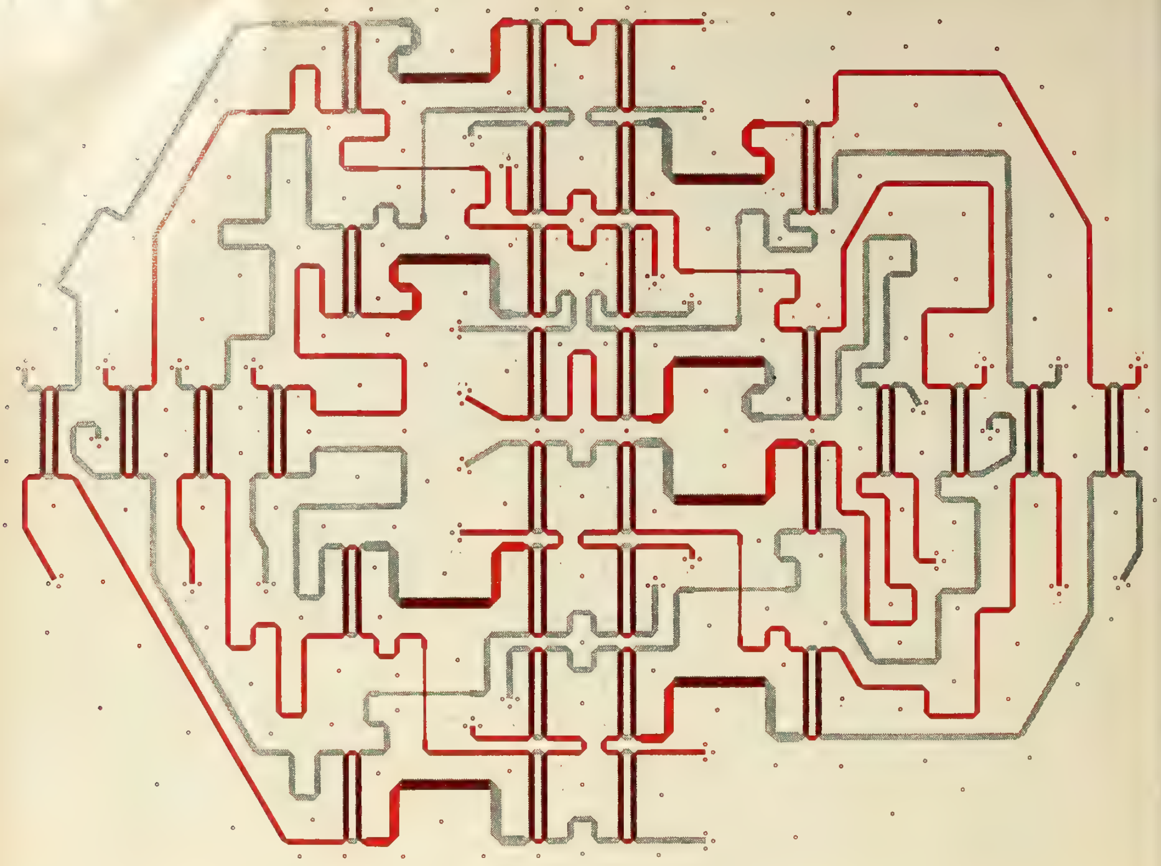
Arrays of 4, 16 and 32 elements have been built by RSI to show proof of principle. One typical application for such a system might be for satellite-to-satellite communications. For such an application, operating at 3 gc, a 40-in. diameter array employing 64 elements could be used, said one RSI spokesman. It would provide a 6-degree beamwidth and a 30-db gain figure.

• **Developed for Air Force**—RSI originated the concept of a cylindrical scanning array using multiple-beam techniques early in 1961. Then, to assist in developing a working prototype, the firm attempted to obtain military R&D funding.

The services expressed considerable interest, but it was not until May, 1962, that the Air Force's Cambridge Research Laboratories finally was able to provide limited funding. A two-phase contract for about $50,000 was awarded to RSI for hardware development.



THIS 16-ELEMENT, octave-bandwidth, multiple-beam array, developed by Radiation Systems, Inc., will provide 360-degree azimuth coverage. Funded in part by Air Force, it has been successfully tested for AF Cambridge Research Laboratories.



BOTH SIDES of matrix board shown in diagram of beam-forming matrix.

The first called for a four-element multiple-beam array and for a similar 16-element array, operating at about 1 gc. The second phase was for much more sophisticated arrays: one, a 32-element multiple-beam array providing eight horizontal beams stacked four high and a capability of steering 360 degrees in azimuth, ±50 degrees in elevation; the other, a 16-element array having very broadband characteristics (operational over the 1 to 2-gc octave).

All four antennas were to be electronically steerable.

All were developed by RSI, with the addition of about $30,000 of company funds, and test-operated successfully within 18 months.

- **Advantages**—Seven major attributes inherent in the RSI cylindrical array concept are stressed by the developers:

—non-mechanical scan capability.
—multiple-beam signal processing.
—full azimuth coverage.
—passive network.
—beam characteristics independent of frequency.
—constant beam gain over azimuth covered.
—reliable, rugged construction.

While existing planar arrays and mechanically scanned aperture antennas offer some of these characteristics, neither provides all.

The RSI multiple-beam cylindrical array concept makes possible the formation of simultaneous multiple beams from a cylindrical array through the use of lossless passive transmission-line networks. Previously such an approach was believed impossible or at least impractical. The specific designs now available, developers claim, are readily applicable over a wide range of frequencies from about 2 mc to 5 gc.

With the existence of such an array, present restraints imposed by the limited angular coverage inherent in planar arrays are eliminated. The system will provide 360-degree coverage with high gain and is capable of operating in a variety of modes, including scanning, at very high rates.

Working models have been developed by RSI and have undergone testing successfully. Patterns obtained during test operation reportedly point to the usefulness of the arrays in such diverse applications as advanced radar systems, direction-finding equipment and multiple satellite information systems for communications, surveillance or reconnaissance.

The array has been proposed, for example, to the Aeronautical Systems Div. at Wright-Patterson AFB, Ohio, as a component of an aerospace system requiring the transfer and processing of signals derived from multiple satellite sources and the transmission of these signals back to Earth. RSI is convinced that use of the inertialess scanning array in this application would achieve a very substantial simplification of an otherwise extremely difficult problem.

• **16-element array**—One task under its AFCRL contract was for RSI to develop a 16-element cylindrical array, capable of 360-degree azimuth coverage with high resolution.

When used as a scanning array, the beam can be swept through 360 degrees using techniques available for scanning a linear array. When used for multiple beam output, the 16 elements are excited by 16 isolated inputs.

Each input is associated with a beam employed in a specific direction and all beams are dispersed symmetrically throughout the 360-degree azimuth angle.

In either mode of operation, the resolution achieved, according to RSI engineers, is comparable to that achieved by a planar aperture of the same height and having a length equivalent to the cylinder array diameter.

RSI established an equivalence between the linear array and its circular array by means of a specialized RF matrix having 16 isolated input ports for exciting the antenna elements. Each element is excited with equal amplitude, but the phase excitation varies from port to port, resulting in a series of omnidirectional modes, each having different phase progressions.

To support this approach, RSI asserts that the mathematical form of these modes (in their pure sense) is identical to that of a single element of a 16-element linear array. The only significant distinction, the firm claims, is the difference between the arguments. That is, in the linear array, the argument is a function of wavelength spacing and azimuth angle, whereas the argument in the cylindrical array is a function only of azimuth angle.

Thus, they stress, this identity of form permits the mode-forming matrix inputs to be treated similarly to the inputs of a linear array.

It was this equating of array processes that permits application of linear array techniques to cylindrical arrays, and the basic task of the AFCRL contract was to experimentally prove the approach with working systems.

• **32-element multiple-beam array**—Under the second phase of the AFCRL contract, RSI engineers developed a 32-element multiple-beam array. This array provided beams at eight azimuth stations with four vertical beams at each of these azimuth stations. The end product was an antenna system which provided instantaneous coverage over a space sector of 360 degrees in azimuth by ±50 degrees in elevation. Each beam utilized the effective cross section aperture of the total structure. This development now makes possible the use of antenna systems that can provide high-gain coverage over large angular areas in space. The RSI sources also note that it would be possible to individually scan these multiple beams at very high rates.

EFFECTS OF TOLERANCES ON COUPLING UNBALANCE

PHYSICAL CHARACTERISTICS	RSI DESIGN	CONVENTIONAL DESIGN
Strip Width (s)	s= 0.062	s= 0.014
Material Thickness (b)	b= 0.188	b= 0.264
Strip Width	0.027 db change/mil	0.1 db change/mil
Material Thickness (center layer)	0.14 db change/mil	0.40 db change/mil

• **Complex matrix**—The 16-port hybrid matrix is used with the 16-element array both for beam-forming and mode-forming. A significant feature of this elaborate stripline assembly, developers say, is that the electrical performance is much less sensitive to mechanical tolerances than is the case in conventional strip transmission line configurations. A comparison between the sensitivity of an RSI-designed 3-db coupler and a coupler of conventional design is striking, as shown in the accompanying table.

The RSI design is less sensitive to mechanical deviations by a factor of about three. This lower sensitivity to changes in line width or material thickness, the firm declares, can lead either to more relaxed tolerances with an attendant reduction in production costs or to improved system performance at more stringent mechanical tolerances.

• **Applications**—The advantages peculiar to the RSI arrays open up many avenues for application.

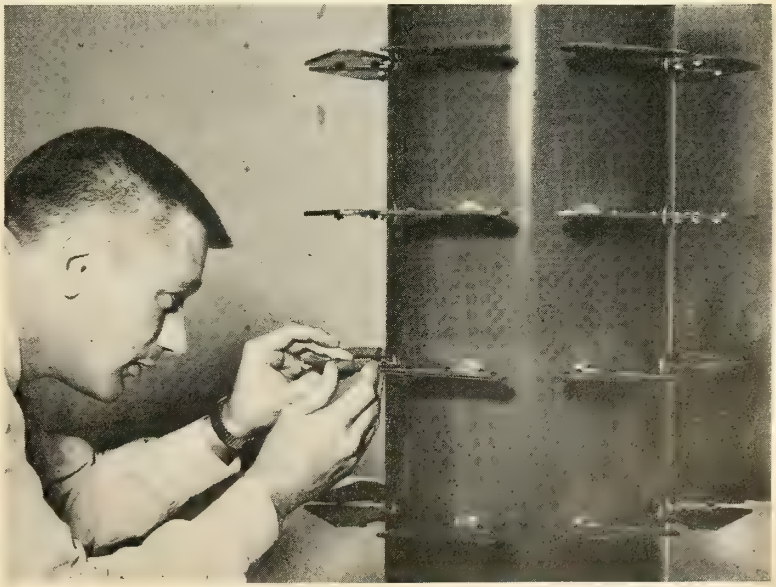
For example, the absence of rotating parts and their relative small size and weight would permit the arrays' use in satellite communications. The ability to transmit and receive multiple signals simultaneously would enhance satellite-relay operation or ground control center communications.

For reconnaissance and direction-finding uses, the systems' wide bandwidth, high gain and simultaneous sector coverage provide unity probability of intercept on all signals, according to RSI engineers.

Also, they point out that the virtual void in the center of the circular array permits unusual packaging possibilities. The space could be employed effectively to house receivers and other signal processing subsystems.

Finally, the design concept permits inertialess scanning for search, track, or track-while-scan radar systems. ■

PRODUCED UNDER AFCRL contract by RSI, this 32-element array provides beams at eight azimuth stations with four vertical beams at each. It provides 360-degree azimuth and ± 50-degree elevation coverage.



SRI Composition Formulations Control Combustion Instability in Solids

Work shows that oxidizer deflagration is key to propellant stability; ozone fluoride research promises elimination of erratic liquid properties

by Willard E. Wilks

MENLO PARK, CALIF.—Stanford Research Institute's Propulsion Sciences Division reports results that may make a significant contribution toward suppressing combustion instability in solid rocket motors.

The division, headed by Dr. Thor L. Smith, currently is seeking a patent covering solid propellant compositions formulated to eliminate unstable combustion under prescribed operational and design constraints. The approach is based upon the application of basic chemical concepts to combustion in the presence of a flow field, and hence it may be applicable to liquid propellant rocket engines.

In addition, the division's recent work in preparation and evaluation of ozone fluoride as an agent to render liquid oxygen hypergolic with liquid hydrogen suggests the compound may aid in suppressing instability in large liquid engines as well as permit multiple start-stop capabilities and increased range safety.

Lionel Dickinson, assistant division director, who formerly was head of rocket engine development at the Canadian Armament Research and Development Establishment, told MISSILES AND ROCKETS that SRI feels it has "a fairly definitive technique for checking the presence of incipient instability in any solid propellant/motor combination."

• **Search for stability**—SRI ran major excursions on ballistic properties and compositional nature of selected propellants to sift out major factors, after Dickinson noted that the erosive and unstable burning characteristics were related to the steady-state ballistic properties.

As a result, "we have been able to modify the combustion characteristics of certain propellants so that they will not respond unstably to a pressure perturbation in the motor. In some instances, we have been able to formulate a propellant that will not go unstable," he said.

"It is the chemical nature of the propellant. It was there all the time. We just had to dig down to get it—study propellants from the standpoint of energy level and ballistic properties and then select the right one. It is a matter of skill in controlling the micro- and macro-ballistic properties of the propellant by modifying the composition."

In recent weeks, firing of a 5-in. x 40-in. solid motor at SRI confirmed that control of oxidizer deflagration is all-important in enabling propellant instability to be controlled or eliminated, according to Dickinson.

There is a practical limit to the maximum pressure at which motors using certain conventional solid propellants can operate stably. Dickinson has developed a method for determining this limit by firing relatively small motors.

"If a propellant is selected without knowing the stability limits, the resulting motor may burn stably many times. But this behavior is statistical," Dickinson said, "for it is related to the occurrence of unanticipated events such as igniter basket breakup, or by a minor flaw opening up, or a structural failure.

"With a small modification of chamber design or a slight drop in quality control, you might suddenly wind up with an unstable motor."

The division is so encouraged with the model it has developed for controlling combustion instability in solids that it plans to consider some aspects of similar types of instability in liquids. It is felt that the approach might well make some contribution toward eliminating similar instability in liquid engines. Instablity occurs because of interaction of the fluid flow processes with the chemical combustion processes, and control of one or the other may eliminate the problem.

• **Ozone fluoride potential**—In its investigation of ozone fluoride, a compound formed by cold electric discharge at 90° K from a mixture of fluoride and oxygen, the division has found that O_3F_2 poses less severe handling problems than had been feared. As a result, its application to large-scale engines is foreseen in the near future.

Experience in SRI labs indicates the hazards are not as great as was originally anticipated. There is no great explosion hazard, and intelligent operational procedures should overcome the compound's thermal instability. Adequate pre-cooling of the chamber should preclude its inadvertent decomposition.

Because of the low concentration of O_3F_2 in the LOX—only 0.05% to achieve saturation—it is felt that the use of ozone fluoride may prove to be very attractive.

The addition of ozone fluoride to LOX will minimize the range safety problem. The hypergolic nature of O_3F_2-saturated LOX promotes rapid burning with the fuel, thus precluding extensive premixing and subsequent detonation of propellants in event of a vehicle malfunction.

Belief that use of the compound also may be an aid in suppressing combustion instability in large liquid engines is based on the fact that it modifies the combustion process, promoting the overall chemical reaction.

Ozone fluoride is reasonably stable at temperatures below 110° K and is in itself an extremely energetic oxidizing agent, so much so that a very dilute solution renders liquid oxygen hypergolic with certain fuels.

Because of this unique characteristic, SRI is conducting for NASA a detailed study of its physical and chemical properties together with an experimental investigation of the hypergolic ignition processes occurring between liquid hydrogen and LOX so treated.

Preliminary data show that small ignition delays are obtained for this system at 90° K. A small quartz combustion chamber has been designed by the SRI division to permit photographic as well as instrumental studies of the ignition processes. The chamber can be cooled or evacuated to simulated various space environments.

A missile company is proposing a study of large-scale use of ozone fluoride, and at least one chemical company has been seeking information on method of production.

- **Extensive solids work**—The SRI division's effort is somewhat greater in solids than in liquids. Solid propellant investigations include, in addition to that on combustion instability, research into special propellant formulations which bear on: the stop-start problem; improved curing agents; microwave attenuation; mechanical properties of propellants; and improved propellant binders.

In the stop-start work, the division has a program underway to modify propellants to achieve compositions that will extinguish better under pressure drop. It is looking into control of combustion at low pressures, seeking to develop propellants that will extinguish under a low rate of depressurization. It also is investigating propellants that extinguish with a transient pressure increase rather than rapid depressurization.

The Division has been successful in obtaining the desired characteristics in propellants that have been tested in small-scale motors. It is now preparing for a scale-up test. Propellants containing alkali metal halides have been studied in this program.

The division recently fired a 5-lb. grain stop-start motor with a variable area plug nozzle and achieved sharp termination of thrust with a drop from chamber to ambient pressure. Propellant ballistics had been modified to achieve a motor in which burning decays rapidly with pressure drop. A scale-up test is being prepared.

Efforts are also being directed toward development of low-temperature curing agents to minimize the strains induced during curing of large solid grains. This work has led to methods for effecting low-temperature cure on some of the newer binder systems. Good mechanical properties and improved storage stability are sought. Propellants based on carboxy-terminated polybutadiene polymers are used in the investigations.

- **Communications problems**—Microwave attenuation work involves study of the influence of rocket exhaust plasma on transmission of microwaves used for communications and navigational purposes of space probes.

Effort is directed toward design of a motor to minimize microwave attenuation, as well as to specifically determine which propellant ingredients, particularly minor additives, control attenuation. This will enable the best propellant/motor combination to be selected in order to minimize the problem.

Studies of propellant mechanical properties include investigation of the change in volume that occurs under various test conditions. The volume increase is the result of microscopic adhesion failure between the rubbery propellant binder and the oxidizer particles. This de-wetting process, involving adhesion failure at the binder-oxidizer interface, creating vacuoles in the grain, is believed to control to a high degree the stress-strain characteristics in solids. When a solid grain is even moderately deformed, de-wetting begins.

One way to study the de-wetting process is to determine the volume changes that occur when a propellant is subjected to a given stress- or strain-time history. For this, SRI researchers have developed a special air dilatometer. A sample is enclosed in a chamber, and when the specimen's volume increases, the slight pressure increase that occurs in the surrounding air is measured. From the data, the volume increase of the specimen can be calculated.

Some work is under way on the behavior of elastomers and plastics under simulated space conditions. This involves polymers for special applications such as propellant binders, adhesives, fiber-glass laminates, and flexible foams. Included in the polymer work are fundamental studies on polymerization; this work could lead to improved propellant binders with superior aging characteristics.

- **Division's work scope**—About 90% of the division's work, involving more than a dozen projects, is government-funded. Employing about 60 persons, the division has a budget of about $1 million annually.

Projects include: Phenomenological aspects of combustion instability (Air Force/ARPA); relations between chemical structure and ability to be detonated of high-energy compounds (ARPA/Office of Naval Research); several projects dealing with synthesis of high-energy oxidizers and fuels (ARPA); preparation and evaluation of ozone fluoride (NASA); solid propellant mechanical properties, including de-wetting process (Air Force); investigation of the viscoelastic properties of solids, including studies of the dynamic shear properties and bulk compresibility (ARPA/BuWeps); and fundamental studies relating to inorganic oxidizers (ARPA/Air Force).

Projects not tied to propulsion include work directed toward determination of the factors that affect the strength of elastomers (Air Force), study of the mechanical properties of plastics under simulated space environment conditions (NASA), and work on non-flammable high-temperature-resistant hydraulic fluids and lubricants (Navy). ■

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Hybrids Work Geared To Lunar Survey Role

by Warren Burkett

THE MANNED Spacecraft Center plans to finance a $300,000 hybrid rocket development program soon. The nine-month program will be aimed at producing hybrid rockets of throttleable thrust up to 1,000 lbs.

The development program will follow $100,000 in theoretical studies conducted for MSC by Lockheed Propulsion Co. "Now we want to produce some hardware," says J. G. Thibodaux, chief of the MSC Propulsion and Energy Systems Div.

Thibodaux sees the MSC program as filling a gap to be left when the government's Advanced Research Projects Agency (ARPA) restricts funding of hybrid rocket programs. The Army may continue funding research in hybrids for special purposes.

The request for proposal has been written in the MSC program and needs only final approval by headquarters for issuance.

Design goal of the program will be to produce a rocket capable of allowing a reconnaissance package to hover over the lunar surface for a close-up aerial survey of possible landing sites. This particular mission was chosen to present "a realistic design problem" for the development program, said Thibodaux.

Thibodaux hopes for an advance in the hybrid-rocket state of the art to improve reliability and increase knowledge of burning characteristics of the solid-fuel charge. In these areas, he said, the hybrid rocket now stands at about the same place liquid rockets did 10 years ago.

Hybrid rockets offer manned spaceflight two potential advantages. Thibodaux outlines these as 1) simplified variability of thrust and plumbing in the liquid system, and 2) re-start capability plus the higher volumetric loading characteristics of solid fuel rockets.

- **Burning questions**—The major problem to be solved in the development program involves knowledge of the actual burning characteristics of the solid fuel, Thibodaux says. At present there is considerable uncertainty in designing hybrid rockets that maximize the combined burning of both fuel and oxidizer.

This becomes a matter of making sure that both fuel and oxidizer come out even. In the case of liquid fuels, this can be done automatically through sensors that measure the consumption rates and vary the mixture ratio within known limits. For solids, the original ratio of fuel to oxidizer in the formula also controls this consumption rate automatically. However, throttling attempts with solid rockets have not proven very successful, said Thibodaux.

Major problems in throttling solids are created by the high-temperature, corrosive environment in which the solid-rocket throttling mechanism must work within close tolerances.

Hybrids pose an entirely different set of burning problems. Fuel burns fastest close to the point of oxidizer injection, usually at the end of the core farthest from the nozzle. Maintaining a flow of material out the nozzle requires high-pressure operation throughout the system, and the oxidizer pressure must remain higher than the pressure in the combustion chamber.

Lockheed studies indicate that the weight penalty, burning and reliability problem may be solved by special shapes of the F-charge design.

- **Late start**—Although hybrids have been known since the late 1940's, principally through the work of Dr. William Avery at the Applied Physics Laboratory at Johns Hopkins University, they have not been given the study accorded liquids and solids.

Dr. Avery, General Electric and the old Grand Central Rocket Co. (now Lockheed Propulsion Co.) achieved respectable thrusts by using plastic and other hydrocarbon fuels. For instance, rockets of 20,000 lbs. thrust were achieved in the old *Hermes* program with discs of polyethylene for fuel and hydrogen peroxide decomposed by a catalyst.

With metal additives, thrusts with specific impulses of 235 to 245 seconds appear feasible. Plumbing will be simplified by at least one half, Thibodaux said, when only one fluid is used to control the burning rate. ■

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The Industry Week

New Activities

North American Aviation, Inc.'s Autonetics Div., Anaheim, Calif., has established a new subdivision, Research, Engineering and Reliability. C. F. O'Donnell is vice president of the division and E. H. Schaefer is executive director. . . . *United Control Corp., Redmond, Wash., has established an Industrial Products Div., aimed at consolidating the firm's expanding activities in nondefense areas. Walter Page was named general manager.* . . . A new company, Pyrogenics, Inc., has been formed by Johns-Manville Corp., New York City, and Space Age Materials Corp., Woodside, N.Y. The new firm will incorporate SAMC's pyrolytic graphite manufacturing facilities and personnel to produce high-temperature insulations for the missile/space industry. J-M will invest in the new company and act as national sales representatives. . . . *Beckman Instruments, Inc., Fullerton, Calif., has centralized its analog and hybrid computer programs in Beckman Computer Operations. The organization will be located in Richmond, Calif., and headed by Dr. Maxwell C. Gilliland.* . . . Dow Corning Corp., Midland, Mich., has formed a group of missile/space applications laboratories "to speed advanced research, evaluation and development work on new or improved materials for the nation's space program." The new facilities include an ablation laboratory and a space simulation laboratory.

Mergers and Acquisitions

Perkin-Elmer Corp., Norwalk, Conn., has purchased Coleman Instruments, Inc., Maywood, Ill., producer of medical instruments. Coleman will be operated as a P-E subsidiary under present management. . . . *Thompson Ramo Wooldridge, Inc., Cleveland, Ohio, has offered to buy 250,000 shares of its common stock at $56 a share. The offer will expire Mar. 17.*

In The Courts

JFC Electronics Corp., Brooklyn, N.Y., and Oxford, N.C., has filed a patent infringement suit against Roanwell Corp., New York City. JFD charges that Roanwell is marketing a coaxial trimmer capacitor patented by JFD.

International

Power Equipment Div. of Lear Siegler, Inc., Cleveland, Ohio, has acquired 75% interest in Aircraft Appliances and Equipment, Ltd., Toronto, Canada. AAE deals with electronic, electric and hydraulic assemblies, power generating equipment and test instruments. . . . *Nesco Instruments Div. of Datapulse, Inc., Inglewood, Calif., has named P. J. Kipp & Zonen, Bergisch Gladbach, West Germany, as exclusive dealer for its line of strip chart recorders in West Germany.*

New Facilities

Westinghouse Defense and Space Center has established a Product Support Equipment Dept. at its new plant in suburban Baltimore, Md. The department will design and manufacture test equipment to assure reliability of electronic systems produced by the Center. . . . *Construction has been started at NASA's Merritt Island Launch Area on tall "explosive safe" buildings to be used in the Surveyor, Mariner and Voyager programs. One building will be used for sterlization and assembly; the other will house equipment for fueling spacecraft before delivery to launch pads. Completion date has been set for late summer.* . . . Construction of a $6-million NASA test facility for *Centaur/Surveyor* space vehicles has been begun by Nielsen Construction Co., in San Diego, Calif. General Dynamics Corp.'s Astronautics Div. will supervise construction and equip and operate the facility for NASA's Lewis Research Center. The facility will be used to rehearse the space vehicles before lunar missions. . . . *Allmetal Screw Products Co., Inc., Garden City, N.Y., has opened a regional sales office and warehouse in Needham Heights, Mass. Gene Conner has been named regional manager.* . . . General Precision, Inc.'s Librascope Metrology Laboratory has moved to a 15,000-sq.-ft. building in Van Nuys, Calif. . . . *Aztec Enterprises, Inc., Albuquerque, N.M., has been appointed exclusive representative for Raymond Engineering Laboratory, Inc., Middletown, Conn., research, development and manufacturing firm for the missile/space industry. Aztec has opened a branch office in Phoenix, Ariz.* . . . Razdow Laboratories, Inc., Newark, N.J., has delivered Mark II rate measurement systems to Bendix Corp.'s Foundries Div. in Teterboro, N.J., and SAGEM, Paris, France.

Company Representatives

Pyle-National Co., Chicago, has opened a sales engineering office in Dallas to handle its line of environmental electrical connectors in that area. . . . *Michigan Wire Cloth Div. of Michigan-Dynamics, Inc., Detroit, has named Murdock-Cave & Co., Chicago, as manufacturers representative for Indiana, Illinois, Iowa and Wisconsin.* . . . H&H Machine Co., Inc., has appointed Paul Selinger & Co., sales representative for its line of small metal tubular parts and coil forms in the Chicago area. . . . *National Semiconductor Corp., Danbury, Conn., has appointed Black & Strong, Inc., Los Angeles, as sales representative for southern California. NSC manufactures silicon transistors and integrated circuits devices.* . . . Raytheon Co., Lexington, Mass., has named Perlmuth Electronics, Phoenix, Ariz., industrial distributor for the company's electronic products in Arizona. . . . *Packard Bell Computer, Santa Ana, Calif., has named WKM Associates, Inc., to handle its products in a major eastern area. WKM has offices in Cleveland, Ohio, Pittsburgh, Pa., Detroit, Mich., and Dayton, Ohio.*

AWARDS

AIR FORCE

$9,900,000—**Martin Marietta Corp.**, Denver, for additional work on *Titan II* ICBM's.

$8,691,400—**Radio Corp. of America,** New York City, for purchase of formerly leased electronic data processing equipment at West Palm Beach, Fla.

$4,600,000—**Douglas Aircraft Co.,** Santa Monica, Calif., for space launch services.

$3,800,000—**Ford Motor Co.,** Palo Alto, Calif., for additional work on a satellite contract network.

$3,000,000—**Ford Motor Co.,** Dearborn, Mich., for purchase of formerly leased electronic data processing equipment.

$1,800,000—**Sylvania Electric Products, Inc.,** Mountain View, Calif., for a classified electronics effort.

$1,600,000—**American Bosch Arma Corp.,** Garden City, N.Y., for further *Atlas* missile inertial guidance system research and development.

$1,000,000—**General Electric Co.,** Syracuse, N.Y., for designing equipment for an advanced radio guidance system.

$726,711—**Sperry Gyroscope Co.,** Great Neck, N.Y., for performance of program-definition studies for a standardized space guidance system (SSGS).

$700,000—**International Business Machines Corp.,** New York City, for performance of program-definition studies for a standardized space guidance system (SSGS).

$487,000—**Radio Engineering Laboratories of the Dynamics Corp. of America,** Long Island City, N.Y., for purchase of monitors for the European Mediterranean tropospheric communications system, and England-to-Turkey radio relay system.

$425,000—**Texaco, Inc.,** New York City, for research in conventional and unconventional fuel cells.

$380,000—**TRW Space Technology Laboratories, Inc.,** Redondo Beach, Calif., for performance of program-definition studies for a standardized space guidance system (SSGS).

$368,293—**United Technology Center,** Sunnyvale, Calif., for an exploratory development program of an advanced throttling concept.

$300,000—**North American Aviation,** El Segundo, Calif., for performance of program-definition studies for a standardized space guidance system (SSGS).

$282,976—**Union Carbide Corp.,** New York City, for research and development of metal hydrides.

$223,000—**Philco Corp., Aeronutronic Div.,** Newport Beach, Calif., for development of rocket nozzles.

$84,279—**Sperry Rand Corp.,** Great Neck, N.Y., for development of a high-power, continuous wave, electroluminescent radiation source for avionic system applications.

Republic Aviation Corp., Farmingdale, N.Y., for a study of the influence of diets on the bacterial flora of chimpanzees (undisclosed amount).

ARMY

$121,300,000—**Morrison-Knudsen Co., Utah Construction & Mining Co., Perini Corp., and C. H. Leavell & Co.** (joint venture), for construction of *Minuteman* missile launch facilities in North Dakota.

$5,600,000—**Radio Corp. of America,** Camden, N.J., for purchase of formerly leased automatic data processing equipment.

$1,475,000—**General Dynamics/Pomona,** Calif., for continued research and development of the *Redeye* missile system.

$1,300,000—**Kaiser Aerospace and Electronics Corp.,** San Leandro, Calif., for *Pershing* missile first-stage and second-stage motor nozzle production.

$1,000,000—**Aircraft Armaments, Inc.,** Cockeysville, Md., for engineering services on the *Nike-Hercules* antimissile missile.

$1,000,000—**General Dynamics/Pomona,** Calif., feasibility validation of the *Mauler* weapon system.

$258,000—**Martin Co., Orlando Div.,** Fla., for modification of BIRDIE systems.

$40,976—**Advanced Communications, Inc.,** Chatsworth, Calif., for missile-borne distance measuring equipment.

$37,406—**Western Electric Co.,** Whippany, N.Y., for rebuilding *Nike-Hercules* gyroscopes.

NAVY

$1,500,000—**Computer Measurements Co.,** San Fernando, Calif., for the design and production of electronic counters.

$1,005,000—**Burroughs Corp.,** Detroit, for communications equipment.

$205,000—**Raytheon Co.,** Bedford, Mass., for procurement of facilities involving *Sparrow III* program.

$179,803—**Techni Data Laboratories,** Lomita, Calif., for telemetry ground station equipment.

$125,000—**Callery Chemical Co.,** Callery, Pa., for research and development in high-energy fuels and oxidizers for rocket propellants.

$64,350—**Sylvania Electric Products, Inc., Semiconductor Div.,** Woburn, Mass., for production of germanium mesa switching transistors.

NASA

$16,500,000—**Chrysler Corp.,** Highland Park, Mich., for added services supporting *Saturn* rockets and space centers (three contracts).

$12,200,000—**Douglas Aircraft Co.,** Santa Monica, for launch services and research vehicles relating to the *Delta* booster with work to be done at the Atlantic Missile Range.

$3,100,000—**Ling-Temco-Vought, Inc.,** Dallas, for administrative and management services at Cape Kennedy's MILA complex and Huntsville, Ala., areas.

$1,100,000—**Hughes Aircraft Co.,** Malibu, Calif., for follow-on program of ion rocket engine development.

$939,000—**General Dynamics/Electronics,** San Diego, for 39 telemetering equipments.

$800,000—**Ball Brothers Research Co.,** Boulder, Colo., for construction of the last five of the eight planned *Orbiting Solar Observatories*.

$144,000—**Mosser Construction Co.,** for addition to central control facility for rocket systems research project C-3562 with work to be done at Lewis Research Center, Cleveland.

$63,685—**Lockheed Aircraft Corp., Missiles and Space Co.,** Sunnyvale, Calif., for a study to extend the theory of minimum-effort control of low-thrust vehicles.

$52,700—**Aerojet-General Corp., Nucleonics Div.,** El Monte, Calif., for design and construction of an underwater carrier capable of nuclear reactor transportation at Plum Brook Station, Sandusky, Ohio.

$48,839—**Thompson Ramo Wooldridge, Inc.,** Cleveland, for incremental funding for Project Sunflower.

$43,276—**Philco Corp., Western Development Laboratories,** Palo Alto, Calif., for operational and functional analysis of space flight guidance facility.

$39,503—**Collins Radio Co.,** Dallas, for communications ground systems service.

INDUSTRY

$1,500,000—**Ameircan Machine & Foundry Co.,** New York City, from **Martin Marietta,** for updating 50 *Titan I* launcher systems originally installed in 1962 by the firm for the Air Force.

$250,000—**American Potash and Chemical Co.,** Henderson, Nev., from **Lockheed Propulsion Co.,** for chemical ingredients to support Lockheed's 156-in. solid rocket motor program.

$100,000—**American Synthetic Rubber Corp.,** Louisville, Ky., from **Lockheed Propulsion Co.,** for chemicals to support Lockheed's 156-in. solid rocket motor program.

$75,000—**Ormond, Inc.,** Santa Fe Springs, Calif., from **Lockheed Propulsion Co.,** for a thrust stand force measuring system to support Lockheed's 156-in. solid rocket motor program.

$60,000—**Interchemical Corp.,** New York City, from **Lockheed Propulsion Co.,** for chemicals to support Lockheed's 156-in. solid-rocket-motor program.

$25,000—**Studebaker-Packard Corp., C.T.L. Div.,** Santa Ana, Calif., from **Lockheed Propulsion Co.,** for a nozzle assembly.

$25,000—**Capital Westward, Inc.,** Beaumont, Calif., from **Lockheed Propulsion Co.,** for modification of the test bay at Lockheed's Potrero facility.

International Telephone and Telegraph Corp., Industrial Products Div., San Fernando, Calif., from **General Dynamics Corp.,** for a static inverter for the Satellite for Aerospace Research (undisclosed amount).

Goodyear Aerospace Corp., Aviation Products Div., Akron, Ohio, from **Hercules Powder Co.,** for fabrication of liners for the second stage of the *A3* submarine-fired *Polaris* (undisclosed amount).

FOREIGN

$3,500,000—**Raytheon Co., Space and Information Systems Div.,** Santa Barbara, Calif., for production of electronic systems for the United Kingdom.

$2,000,000—**North American Aviation, Inc., Autonetics Div.,** Anaheim, Calif., for production of inertial navigation systems for *Polaris* submarines for the United Kingdom.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

U.S. Army Missile Command
Procurement and Production
Special Contracts Div.
Contract Negotiation Branch
Redstone Arsenal, Ala.

Selected source research procurement for the development of high-speed photodiode detectors with Electro-Nuclear Laboratories, 2433 Leghorn St., Mountain View, Calif. It is suggested that small business firms and others interested in subcontracting opportunities make direct contact with the above firm.

Headquarters
Space Systems Div.
AF Unit Post Office
Los Angeles 45, Calif.

Contract for research and development to provide a military space systems analysis study to be negotiated with Planning Research Corp., Los Angeles, Calif. PR 64-SSD-316. Note: For information only; RFP not available.

U.S. Army Missile Command
Procurement and Production
Special Contracts Div.
Contracts Negotiation Branch
Redstone Arsenal, Ala.

Selected source procurement for high-energy propellant research with Thiokol Chemical Corp., Elkton, Md. It is suggested that small business firms and others interested in subcontracting opportunities make direct contact with the above firm.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio

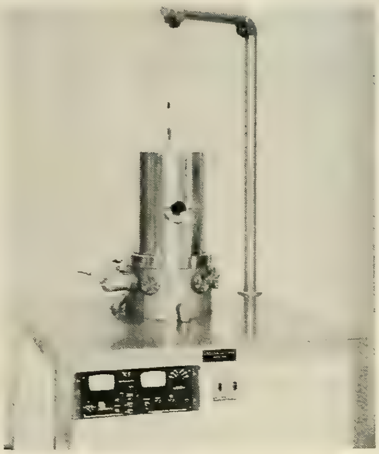
Exhaust duct for nuclear rocket test stand to be installed at the nuclear rocket development station near Mercury, Nev. System to consist of 48-in. diameter stainless steel "L" shaped duct with associated water-cooled pipe support truss instrumentation testing and installation in accordance with specs and applicable drawings. Only those firms that show evidence of their qualifications in complicated stainless steel fabrication and associated instrumentation will be given bid packages. The procurement officer may order a facility survey of any requestor of bid package. RFP SNPC-23. Bid opening 4-10-64. If further information is desired, contact W. P. McCue or R. D. Clingman of Space Nuclear Propulsion Office Cleveland.

New Product of the Week: Vacuum Chamber

An ultrahigh vacuum chamber equipped with up to 13 integral feed-through ports is being marketed by Vacuum Industries, Inc.

The Model 1218 was designed for outgassing studies, component evaluation, or materials and lubricants testing in a simulated space environment. It has a straight-through vacuum pumping system utilizing a 6-in. diffusion pump with low impedance liquid nitrogen cold trap. The unit's 12 x 18-in. vaccum chamber can provide a simulated space environment to 3×10^{-8} torr in less than an hour without baking. Pressures to 10^{-10} torr can be obtained by substituting metal gaskets for elastomer seals.

Circle No. 151 on Subscriber Service Card



Plasma-Arc Generator

Creare, Inc., has developed the Model PAG-2 plasma-arc generator for use in materials, physics and chemical research applications.

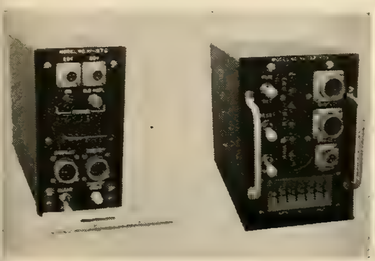
The device has a flexible design that allows a number of duct configurations; the injection of gases, liquids and powders into the plasma; and insertion of various types of probes. Typical performance of the device using helium in a duct 1 cm. in diameter and 6.35 cm. long is: voltage drop—approximately 175v dc at 30 amperes, 100v dc at 300 amperes; helium flow—approximately 0 to 1 gm/sec; gas temperatures to 20,000° K at flow centerline.

Circle No. 152 on Subscriber Service Card

Time Code Generator

Digital Products Div. of Hyperion Industries, Inc., is marketing the Model HI-187-G airborne time code generator.

The unit has a power consumption of 9.8 watts at 24 to 31v dc; 105 to 125v ac, 400 cps, input is available. Overall timing accuracy is 0.005% within a temperature range of —55° to 85° C, 100° C operation on special order. Output is a pulse-height, pulse-width one kc modulated signal at a bit rate of 25 pps. Format is binary coded decimal in hours, minutes and seconds.



Circle No. 153 on Subscriber Service Card

Vacuum Fuse

Thermal Controls, Inc., has introduced a line of high-voltage vacuum fuses that prevent momentary or sustained arcing when a fusible element ruptures.

The units are designed to glow when operating at normal load. Location of equipment failure can be localized by noting a fuse that is not glowing. The units meet MIL specifications for shock (100 g's) and vibration (5 to 2,000 cps at 40 g's). The fuses are rated at 1,500v dc at 70,000 ft., and are available for normal current loads of 25 to 250 ma.

Circle No. 154 on Subscriber Service Card

Silicon Insulator

A heat-stable, high-strength silicone rubber that can be shrink-fitted to contours of connectors, cables and wire bundles has been developed by Dow Corning.

Called Silastic, the ablative material has application as an insulator or a cable protective during rocket launches. Available in molded parts or tube form, the material shrinks to one-half its supplied diameter when heated briefly at temperatures above 300° F. Standard tubing sizes, after shrinking, range from ⅛-in. in diameter to 1½-in. in diameter. Other sizes and custom-molded shapes are available on special order.

Circle No. 155 on Subscriber Service Card

Signal Source

The Model 2150 signal source, providing a cw or square-wave modulated source of RF power from 2.0 to 4.1 gc, is available from Scientific-Atlanta, Inc.

The device can serve as an antenna pattern range transmitter, a basic oscillator, a parametric amplifier pump oscillator or a general purpose laboratory supply. Oscillator output is coupled through a 3-db pad to a variable 20-db attenuator for control of the RF signal level.

Circle No. 156 on Subscriber Service Card

Transducing Cell

Statham Instruments, Inc., has available a universal transducing cell capable of making measurements of several different physical parameters.

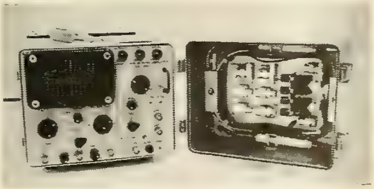
The device has an accuracy of ±0.15% and may be used as a load cell of ±1-ounce range or as a displacement gage of ±0.0015-in. range. Attachments are available to reduce the load range to 0.1 oz. or to extend it to 1, 10, 100 or more pounds.

Circle No. 157 on Subscriber Service Card

Transistorized Oscilloscope

American Electronic Laboratories, Inc., is marketing the Model 725 transistorized oscilloscope. The device meets MIL-E-16400 and MIL-T-4807A specifications.

Vertical channel bandwidth is dc to 5 mc, direct coupled; 2 cps to 6 mc, capacity coupled. Risetime is 70 nanosec.; input impedance is one megohm shunted by 47 pf. Horizontal amplifier bandwidth is dc to 500 kc. Sensitivity is 1v per division, variable to 5v per division. Input impedance is 100 K ohms shunted by 20 pf.



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M/R missiles and rockets

DOD Military System

A Report on the DDR&E

DDR&E, the Directorate of Defense Research and Engineering, is one of the most important offices in the Department of Defense. It has a complement of 145 men, supervising some 30,000 others and directly affecting over 125,000 industry personnel. DDR&E annually contracts for $7 billion dollars in space and military systems research, development, test and engineering services from its suppliers.

The March 30 issue of MISSILES AND ROCKETS will present an in-depth report on DDR&E covering:

DDR&E Operation ▪ Relationships with Industry and the Services ▪ Current & Advanced Programs ▪ In-House R&D Capabilities ▪ Future Expenditures ▪ Key Personnel

Issue Date: March 30, 1964

sue, March 30, 1964

The DOD Military Systems

Issue will be **must** reading for over 45,000 program and project managers, engineers, and scientists in industry and the military. Advertise in this issue to gain maximum exposure for your products, capabilities, or services.

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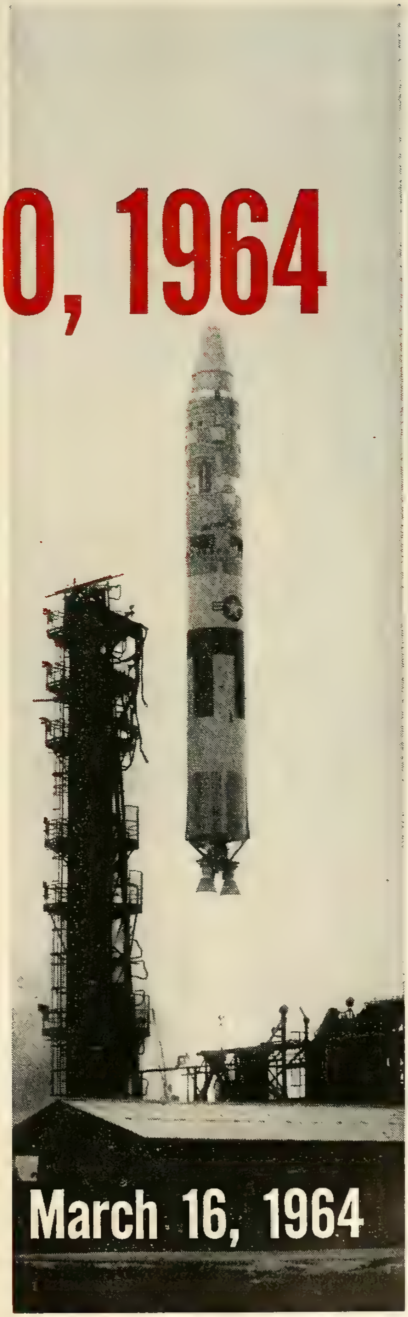
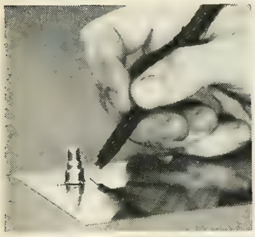
In MISSILES AND ROCKETS — 275 page advertising gain in 1963 over 1962; 3700 new paid subscribers gained during 1963; total paid circulation of over 45,000.



Advertising Closes: March 16, 1964

REFRACTORY METALS
APPLICATION NOTES

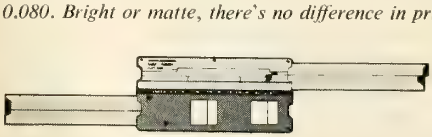
Which moly sheet finish will work best for you–BRIGHT or MATTE?



BRIGHT* finish General Electric molybdenum sheet is eye-appealing, free of almost any surface irregularity, extremely clean. Because it has less surface area than matte, our bright finish is used for vacuum tube and furnace applications where adhesion of gases to the metal might be a problem. Also, this smooth finish is favored for electrical contacts since tendency to stick is minimized. It's a more efficient reflector, too.

MATTE* finish G-E moly sheet has a greater surface area, making it better for plating. It "holds" oil better; so it's preferred for fabricating operations where a lubricant might be required. It's more suitable for brazing. It's more practical for fabricating and applications where metal is heated and may become oxidized—as with "boats" and other furnace hardware. And, matte finish is more desirable for some manufacturing operations since resulting scratches and discoloration are less noticeable.

Either finish may be ordered in thicknesses from 0.005 through 0.080. Bright or matte, there's no difference in price.



Accent on VALUE

MAKE SURE YOU HAVE ALL OF THE FACTS. Write today for a free Tungsten/Moly Conversion and Weight Slide-Rule Calculator and complete data on G-E molybdenum sheet. General Electric Co., Lamp Metals and Components Dept., 21800 Tungsten Road, Cleveland, Ohio 44117.

Progress Is Our Most Important Product
GENERAL ELECTRIC

Circle No. 8 on Subscriber Service Card

Calibration System

Electro Scientific Industries, Inc., is marketing the Model 731 dc ratio and voltage calibration system which provides fully potentiometric voltage calibration to 1,111.110v dc.

Limit of accuracy is 0.0025% of setting or 25 mv. Self-calibration features operated from the front panel allow voltage readings to 5 mv or 25 ppm of reading. Infinite input resistance at null prevents circuit loading effects. Input slewing resistance of approximately 1 megohm prevents circuit damage during balancing.

Circle No. 159 on Subscriber Service Card

20-Channel Recorder

Techni-Rite Electronics, Inc., has developed a 20-channel inkless event recorder, the Model TR-320.

The device monitors up to 20 separate "on-off" events simultaneously on a single heat-sensitive chart, eliminating the need for ink and the danger and fumes of electric wiring.

Rise time exceeds 7 ms with a resolution of less than 3 ms. Other features include: up to 16 chart speeds; built-in chart rewinder; automatic stylus heat control, and choice of signal inputs.

Circle No. 160 on Subscriber Service Card

new literature

MAGNETIC TAPE GLOSSARY—Memorex Corp. has published a "Glossary of Terms Used in Magnetic Tape Recording," aimed at defining and explaining the more fundamental terms of magnetic recording applications. The 12-page monograph, first in a series, lists 177 items.

Circle No. 161 on Subscriber Service Card

CONNECTOR TECHNIQUES PRIMER—"Interconnection and Connector Techniques," an 88-page primer on the characteristics and uses of connectors and contacts has been published by The Deutsch Co., Electronic Components Div. The publication covers such subjects as interconnection in circuit design and interconnection systems; connector selection criteria, nomenclature and terminology; wire and cable specifications and assembly and production techniques.

Circle No. 162 on Subscriber Service Card

TELEMETRY FILTER MONOGRAPH—Kenyon Transformer Co. has available an engineering monograph, "Optimizing Subminiature Subcarrier Telemetry Filters," by Walter Bein. The 4-page, illustrated publication presents a "pre-design" specification technique, designed to permit the telemetry engineer to determine exactly what he wants —electrically, mechanically and economically—by use of standard specifications derived from fundamental system requirements.

Circle No. 163 on Subscriber Service Card

EPOXY RESIN BULLETIN—Epoxylite Corp. has published an 8-page bulletin on epoxy resin formulations designed for electrical manufacturing applications. The publications lists 163 single uses for resin compounds, information on principal catalysts, release agents and strippers, and 27 kits covering a variety of repairs.

Circle No. 164 on Subscriber Service Card

RESISTANCE SOLDERING BOOKLET—American Electrical Heater Co. has available a 16-page booklet, "Principles of Resistance Soldering." The publication explains and illustrates resistance soldering systems, equipment, advantages and range of application. Another section deals with the most frequently asked questions about the method.

Circle No. 165 on Subscriber Service Card

names in the news

James V. Lecocq: Appointed assistant director of public relations for the Allison Div. of General Motors Corp., Indianapolis, Ind.

John E. Duesing: Appointed general manager of the Van Nuys, Calif., division of The Foxboro Co.

Edward J. Doyle: Appointed Federal Systems Div. marketing manager for advanced programs-space at International Business Machines Corp., Rockville, Md.

Clyde C. Hall: Retired public information officer for the National Science Foundation, to operate as a communications consultant in the Washington, D.C. area.

William D. Wilson: Named manager, office of public information at Radiation, Inc., Melbourne, Fla.

Robert L. Wells: Elected vice president-engineering at Westinghouse Electric Corp., Pittsburgh.

Malcolm A. MacIntyre: Elected a vice president of Martin Marietta Corp. and vice chairman of the Bunker-Ramo Corp., Canoga Park, Calif.

Roger B. Neighborgall: Appointed assistant vice president of General Instrument Corp.'s Defense and Engineering Products Group, Washington, D.C. **J. R. Pascuzzo:** Appointed group vice president for Defense and Engineering Products.

Robert L. Trent: Named vice president for research and development of National Semiconductor Corp., Danbury, Conn.

Walter E. Trantham, Jr.: Appointed director of the Southeast region of ITT's Defense and Space Group Field Marketing, Washington, D.C.

Philip R. Gustlin: Appointed assistant secretary of Electronic Specialty Co., Los Angeles. **William M. Rozell** appointed product sales manager.

Philip Ryan: Resigning from the presidency of Cutler-Hammer, Inc., Milwaukee, effective Dec. 31. **Edmund B. Fitzgerald** elected to succeed Mr. Ryan.

Donald C. Nicksay: Appointed general sales manager of the Piezoelectric Div. of Clevite Corp., Bedford, Ohio.

Gilbert W. Robinson: Named manager of the Hartford, Conn., Materials Testing Laboratories Div. of Magnaflux Corp.

Edward Leyman: Appointed director of the Information Systems Div. of Herner and Co., Washington, D.C.

Robert Andrews: Appointed manager-customer relations for the Bomac Div. of Varian Associates, Beverly, Mass.

Otto M. Schiff: Joined the staff of Electro-Optical Instruments, Inc., Monrovia, Calif., as director of manufacturing.

Hubert R. Smith: Joined the staff of Electro-Optical Systems, Inc., Pasadena, Calif., as a senior engineer and sales representative in the Washington, D.C. office.

Laurence M. Doyle: Appointed contracts administration manager at Sparton Corp.'s Sparton Electronics division, Jackson, Mich.

Beauford R. Franklin: Appointed base manager of United Technology Center's operations at Cape Kennedy, Fla.

Victor D. Ellison: Appointed chief engineer for instruments at the Montrose, Pa., division of the Bendix Corp.

William V. Levy: Appointed public relations manager of Goodyear Aerospace Corp., Akron, Ohio.

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A Step Forward

ONE OF THE MAJOR PROBLEMS which has confronted Congress, the Dept. of Defense and the National Aeronautics and Space Administration has been duplication of missions, projects and facilities in the national space program.

A number of steps have been taken to overcome such duplication.

These steps have included the establishment of the *Gemini* Program Planning Board, set up by Secretary of Defense McNamara and NASA Administrator Webb to avoid duplication in the field of manned space flight; centralization of national range management in the hands of the Air Force; and establishment of a joint DOD-NASA fleet of ocean tracking ships.

In view of the great expense of space operations, this trend toward centralization has been not only desirable but inevitable. In a number of cases, Congress has acted to force consolidation by refusing to approve budgets for separate programs or facilities. On occasion, DOD and NASA have moved in this direction of their own accord.

All three bodies deserve public commendation for their efforts. The space program, particularly this year, is under considerable pressure to prove its worth. Every reasonable effort made to cut down on wasteful duplication is to be applauded.

For this reason, we were pleased to see that NASA and the Air Force finally are taking affirmative action to solve the extremely vexsome problem of duplication in the space medicine field (M/R, March 2, p. 10). This has been a touchy issue from the very initiation of the *Apollo* program.

The Air Force, both experienced and eager, already had a large effort underway in bioastronautics, a base which was capable of rapid and easy expansion. The burgeoning space agency, on the other hand, held the only manned mission assignment.

The annual budget exercise on Capitol Hill became a traumatic experience for the administrators of NASA's space medicine program. Although they had the charter, the Air Force had the facilities and the know-how. As a matter of fact, this was not limited to the Air Force. To varying degrees, the other services also possessed a space medicine capability.

At first, NASA denied any intention of mounting a sizable in-house bioastronautics effort. But as the missions beyond *Mercury* were added, space agency officials felt it necessary to expand NASA's technical and managerial capabilities in space medicine.

This was undertaken in a far-from-cooperative atmosphere which saw little communication between the two camps. NASA would issue an RFP only to be informed by a contractor that the Air Force already had the same work under contract—or even completed. Duplication abounded.

Faced with this situation, Congress continued to hack away at NASA's space medicine budget. Last year, for example, $5.7 million was cut from a $16.7-million request. The House Space Committee, in particular, admonished NASA to work out written agreements with DOD by which facilities and work would be shared. Rep. Emilio Q. Daddario (D-Conn.) was one who made this a special area of interest.

His efforts, and those of other members of Congress, now are bearing fruit. Agreement has been reached between NASA and the Air Force to jointly review and assign all space medicine work.

First meetings to this end were held last August at the Air Force Aerospace Medical Division headquarters in San Antonio, Tex., with subsequent meetings at the Manned Spacecraft Center in Houston.

Obviously, all the problems have not yet been worked out, but much has been accomplished. By the end of this month, the first steps in coordinating the bioastronautics effort for Fiscal 1965 will have been taken. Facilities plans will be reviewed shortly. NASA has already helped fund an animal laboratory at Holloman AFB instead of establishing its own lab.

According to Dr. George M. Knauf, NASA's acting director of space medicine, all requests for proposals will be jointly written, program reviews will be jointly conducted and, in some cases, programs may be jointly monitored.

As one result of the coordination agreement, NASA will concern itself largely with those space medicine programs concerned with two-week missions, while the Air Force will undertake those connected with the 30-day mission.

NASA will, however, retain its interest in long-term manned space station bioastronautics studies. Even here, it will utilize DOD's capability in the general area of applied human research.

CONTRACTORS PROPOSING to either agency now will have the benefit of knowing their proposal will be read by the other. This year's effort also will be aided by a computerized review of all the work in the field. This is being carried out by Documentation, Inc., directed by Dr. Eugene Konecci, NASA head of biotechnology and human research.

A NASA liaison office has been established at Aerospace Medical Division headquarters, manned by Lt. Col. Grady Wise, an Air Force medical officer.

Joint meetings to date have resulted in the cancellation of 55 projects—47 in the Air Force and eight in NASA.

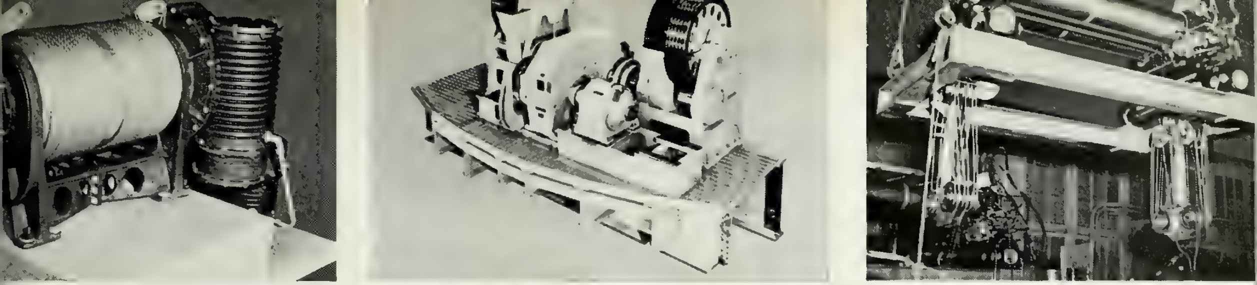
Authors of the program were Dr. Knauf and Maj. Gen. T. C. Bedwell and Col. John Talbot of the Air Force.

The working groups who brought all this about were headed by Col. John Pickering, deputy director of research and engineering at the Aerospace Medical Division, and Richard Johnston, director of the crew systems division at Manned Spacecraft Center.

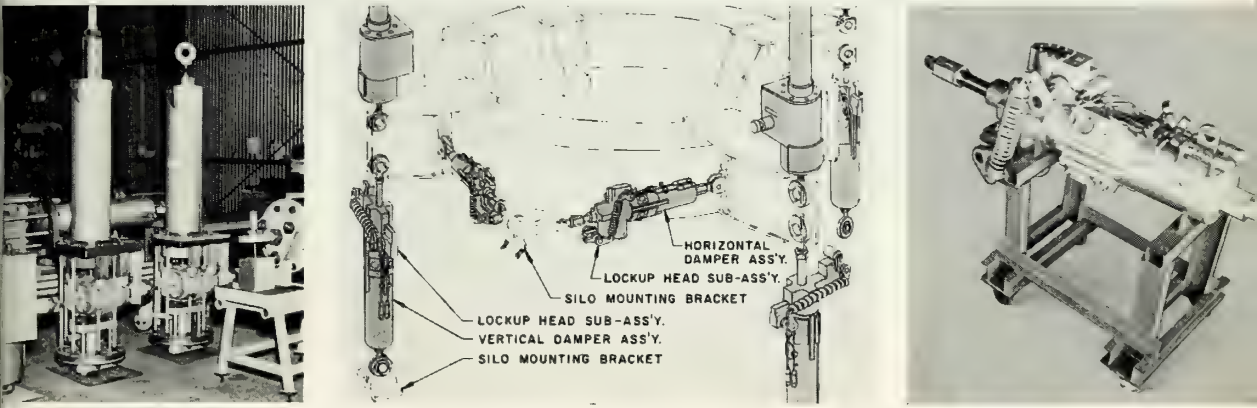
This agreement has brought to an end the wasteful strife between the two major agencies in the field. Efforts also have been coordinated with others working in biomedicine, including the Army, Navy, Federal Aviation Agency and the Dept. of Health, Education and Welfare.

All who had a part in this are to be highly complimented, including such members of Congress as Rep. Daddario. It is a major contribution.

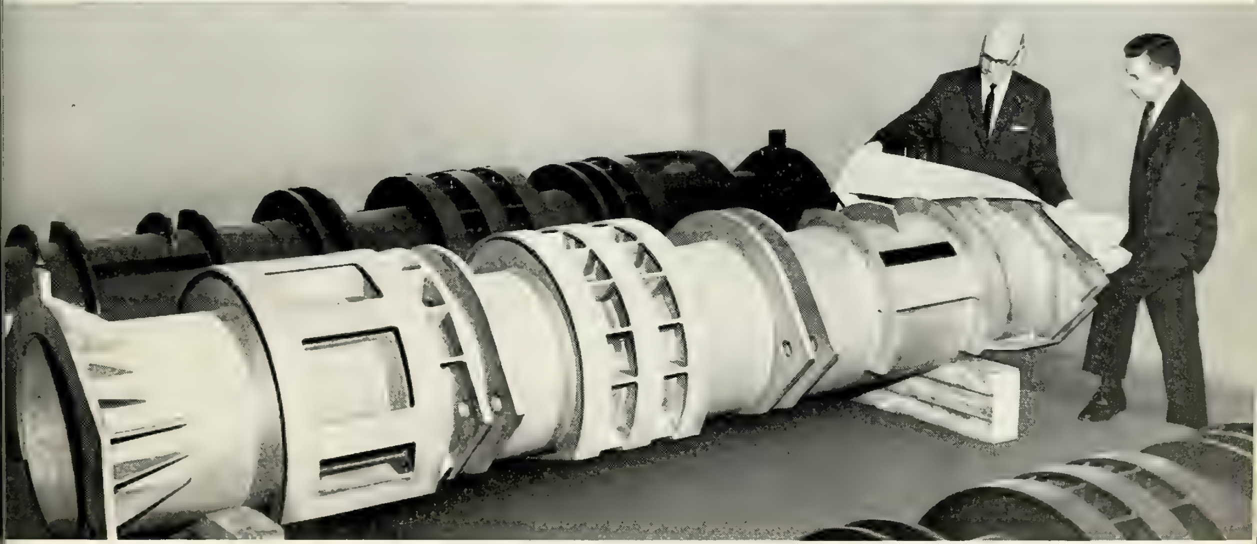
William J. Coughlin



HOISTS—Western supplies these heavy duty hoists for (1) Nike Zeus (2) Atlas and (3) Minuteman missiles.



SHOCK ISOLATION—Vertical and Horizontal damper assemblies of Western's Shock Isolation System for the Titan II.



SPRING CAN ASSEMBLIES—Built by Western as a precision component in the Minuteman missile silo system.

...and now they're calling us the "missile muscle men"

Surprised? This heavy equipment for missile ground handling and positioning is far removed from the lightweight airborne gear drives you probably know us for. You'll want to keep track of how our capabilities keep growing.

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THE SKEPTICAL MEN AND THE MICROELECTRONIC COMPUTER Perfection is a microcosm. Its pathways today are often the branches of intricate electronic circuits—so small that few can conceive of them. But there are some who probe these pathways with growing confidence: the creative electronics scientists of aerospace.

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Throughout the industry, men like these are exploring the mazes of perfection. In the courts of their minds, even perfection itself is always on trial, and acquittal is never final. For these are the skeptical men.

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MARCH 16, 1964

nissiles and rockets

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E WEEKLY OF SPACE SYSTEMS ENGINEERING

enter Segment of First 156-in. Solid at Lockheed

Aan-on-Moon Schedule Slips into '70's . . .

ouse Cuts in NASA Budget Are Minor . . .

lock II Apollo Guidance Has Go-Ahead .

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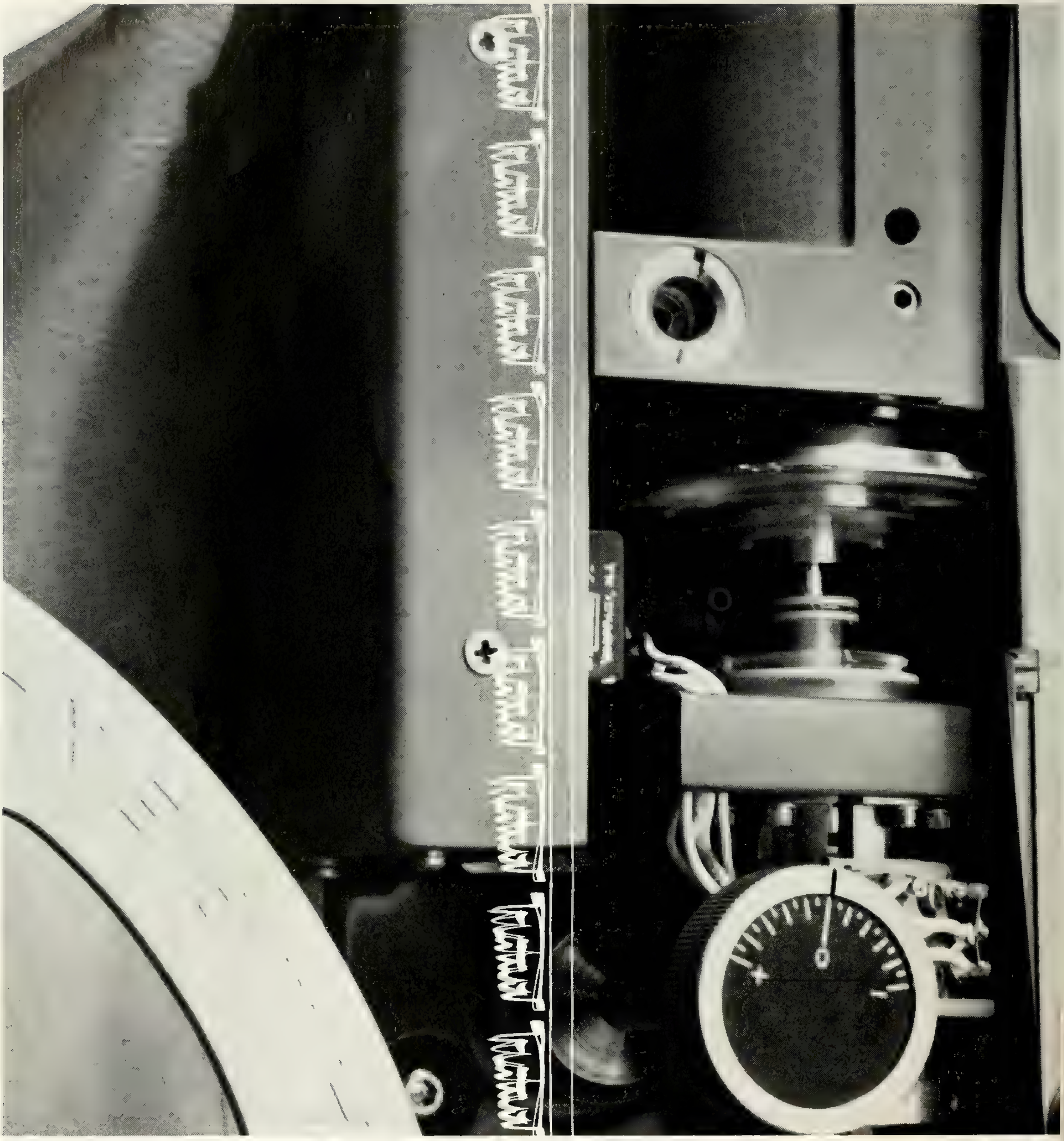

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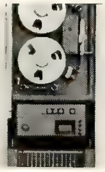

missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING

Volume 14, Number 11 March 16, 1964

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THE COVER

Lockheed Propulsion Co. workers guide center segment of first 156-in. solid motor into casting and curing pit. Motor will be fired late this spring as part of Air Force's large solid rocket development program. Maraging steel case will be 75 ft. long, with end closures and nozzles. See p. 32.

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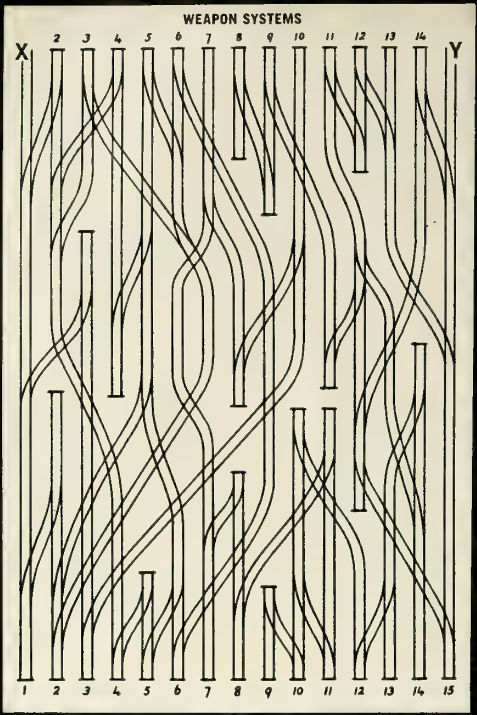

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We guide After a system concept is determined and an industry team is selected by the Air Force, Aerospace co-ordinates, interprets, and guides the efforts of the contractors. Technical meetings are held where ideas are exchanged and system trade-offs discussed. Aerospace sifts and evaluates contractor progress toward the new and improved ballistic missile systems required.

We probe Aerospace scientists are actively engaged in appraising system vulnerability to environment and countermeasures. They must call upon their knowledge of the latest advances in nuclear effects, propellant chemistry, solid-state devices, high-temperature gas dynamics, and electromagnetic wave propagation.

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Take as many as you can of the 39 cars of your train from X to Y. Each time you back out of a siding you lose one car. Can you lose only the minimum of 19? (From *Mazes and Labyrinths, a Book of Puzzles*, by Walter Shepherd; Dover Publications, Inc., New York 14, N. Y.)

AEROSPACE CORPORATION

Organized in the public interest and dedicated to providing objective leadership in the advancement and application of space science and technology for the United States Government

Ranger Management

To the Editor:

Your Feb. 10 editorial ("A $150-Million Failure") was neither the "shotgun condemnation" nor the "impassioned outburst" that Messrs. Schmidt and Winslow contend in their letters to the editor (Feb. 24). Rather, it is their heated replies, complete with the conspicuously unspecific castigations of industry performance on *Mercury*, *Titan* and the Nuclear Submarine Program, that merit the appellations they so graciously offer.

The somewhat more measured response of Mr. Thompson (Letters, March 2) only further displays the acute defensiveness that characterizes these efforts to rebut your charges. A careful reading of each letter only lends support to your basic thesis that the attainment of our defense and space goals requires a sanguinary and firm-minded grasp of reality and necessity that is fundamentally foreign to the intellectual precision of an academic environment.

There is a well-defined place in our defense and space activities for the academically related laboratories. It lies in the area of scientific investigation—not in the areas of system engineering and program management.

Certainly, industry and the nation are much in the debt of the nonprofit laboratories for their science contributions. Nevertheless, as you rightly noted, it is only in a "hard-driving industrial atmosphere" that these contributions can be engineered to meet the stringent requirements of military and space application.

Ranger VI was but the most recent and conspicuous example of the consequences that attend the unwarranted extension of the scientific community into industrial realms. Time, in its immutable course, will present us with other examples.

Already Congressional and industry spokesmen have begun to question the performance of the MIT Instrumentation Laboratory as guidance managers for *Apollo*. The heated contentions of Mr. Schmidt notwithstanding, the past record of MIT does not offer any very great assurances that system engineering is any better understood there than at JPL.

On the *Polaris* program the inputs of the Instrumentation Laboratory were so esoteric that the Navy ultimately found itself saddled with an 1,800-lb. transit case which required an additional 400 lbs. of lead-acid batteries and an enlisted attendant merely to transport a guidance platform from Charleston, S.C., to Holy Loch, Scotland. This is truly a neat operational requirement for a third-generation guidance unit performing at hardly more than half IRBM range.

By way of contrast, the first-generation, industry-developed *Atlas* ICBM guidance unit and its transit case weigh less than half the *Polaris* figure. In addition, they require no batteries or other support systems in either storage or transit and can travel without attendants over any required distance. Perhaps this lends a little perspective to the current concern for *Apollo*.

You are to be commended for your excellent editorials. They consistently display a keen judgment and a clear voice that should be more widely heard.

Frederick J. Howard
Freeport, N.Y.

Dockless Warehouses

To the Editor:

The other day I came across a report that contained the usual number of dull or behind-schedule items. In the midst of all this normality was an item written to justify the expenditure of funds to provide a loading dock at one of our off-site warehouses. In this day of detailed justification for everything, this one stands out like a bright ray of sunshine.

I have enjoyed it so much that I am hanging a copy on my office wall. I am enclosing it for your readers' enjoyment.

Subject: Warehouse Dock Space

In reply to your request for some observations on why a Warehouse must have a dock, I can only say that it is something like asking "why does an elephant need a trunk?"—because it is in the nature of the beast to be able to operate as an elephant at all, that's why.

A Warehouse is a building used for temporary storage. Material of many sizes and shapes is routed into a Warehouse as a way station, a hold area, in the journey from Supplier to ultimate user. Therefore, material is continuously being unloaded from some source into the building, and material is continuously being unloaded out to someone who needs it. A Warehouse is an organism that ingests and excretes material ceaselessly if it is alive.

Now unless this material is being brought to and taken away from the building in baskets atop the heads of Gurkha bearers, it is usually unloaded out of and loaded back into wheeled vehicles whose floors are generally 41-45 in. above the ground. A dock 43 in. above yard level thus becomes the basic material-handling tool of a Warehouse.

Absence of such a dock creates an inefficient, time-wasting, high-cost, even physically dangerous operation if the level of activity is anything at all above that of a country store. You need more fork-lifts, more people, more space, more Supervision, more patience, resourcefulness and ingenuity (and these are at a premium everywhere, practically extinct); you have more people hurt, more material smashed—you have more of everything you don't want.

A Warehouse is a necessary evil at best, always a potential bottleneck and confusion-factory. It should not be deprived of its trunk—else how can it catch peanuts on Sunday at the zoo?

W. P. Carroll
North American Aviation, Inc.
Downey, Calif.

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X
Y
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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

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Making certain that our ballistic missile forces give strength to our national defense in the years to come is part of the current effort of the Advanced Planning Division, located in San Bernardino, California.

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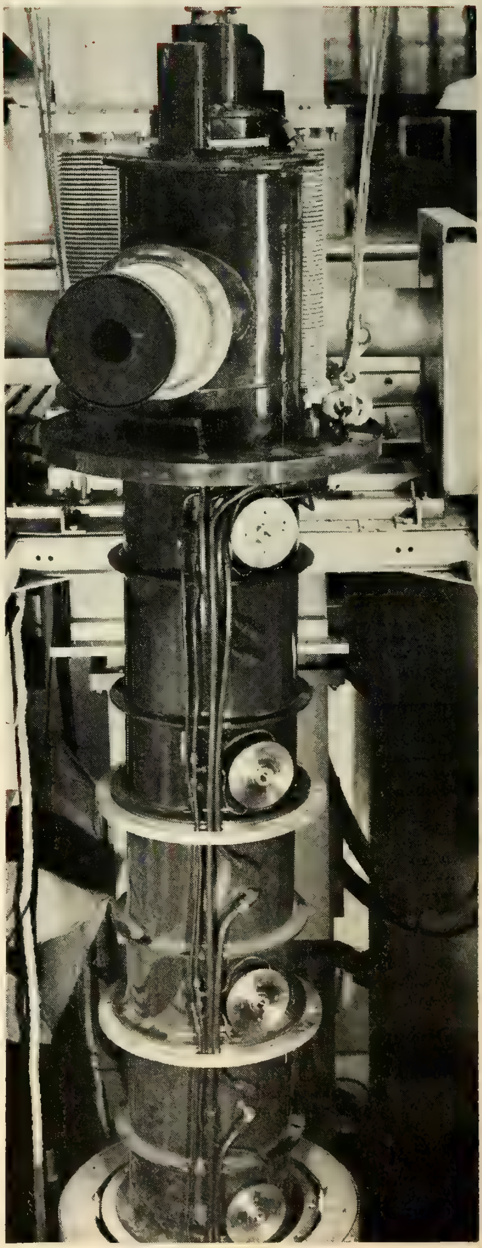

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The Countdown

WASHINGTON

MMRBM May Yet Be Saved

Some Congressional leaders say there still is hope for the badly-battered *Mobile Medium Range Ballistic Missile* program—if Dept. of Defense proves a mission and if suitable international agreements are reached for its deployment. They say reprogramming action could be taken later in the year if the project is justified.

Hawk, Hercules Units to Remain in Florida

Twelve *Nike-Hercules* and *Hawk* firing sites in Florida will remain there as a permanent part of the Continental Air Defense Forces. The units were transferred to the Miami and Key West areas during the 1962 Cuban crisis.

DOD Says No Shelters, No Nike-X

Secretary of Defense McNamara has reaffirmed that he will not recommend deployment of the *Nike-X* system without initiation of a full-scale fallout shelter program. "An anti-ballistic missile system cannot stand alone without a fallout shelter program," he declares. Congressional action on shelters, therefore, could affect *Nike-X* funding.

IMP Discovers New Radiation Zone

Sensors aboard the *Interplanetary Monitoring Probe (IMP)*, now orbiting Earth after its Nov. 26 launch from Cape Kennedy, have detected an extensive region of high-energy radiation beyond the previously known reaches of the Earth's radiation belts. The hitherto-unknown energy zone appears to fan out beyond the Van Allen belts on either side of the Earth and trail off in a kind of "wake" in the direction away from the Sun.

MSC Scrubs Review of Small Contracts

Officials at Manned Spacecraft Center have decided to dispense with legal review of all contracts under $100,000. Reason: an attempt to speed up the center's contracting. Spread of the new management procedure to other NASA field installations is expected.

ARPA Stretches Out Vela Hotel Program

The *Vela Hotel* satellites, produced by TRW Space Technology Laboratories, have been so successful that the Advanced Research Projects Agency has stretched out the launch schedule considerably. This will permit time for developing added sophistication in the next pair.

Congress Questions Comsat Delay

Congress starts probing this week into lack of action on the military communications satellite program. Hearings are planned by the House Government Operations Committee. They want to know the cause of the delay in view of Dept. of Defense testimony last April which stressed the urgent need for the military comsat.

NASA Takes New Look at Reusable Boosters

NASA is looking with greater interest at reusable booster concepts. The space agency is encouraging industry to do likewise. Tightening of space program funds is a major reason, according to some observers. Hypersonic ramjets are receiving serious consideration.

NASA Studies Mission Outside Capsule

Before design of the extravehicular environmental control system can proceed, NASA must decide what missions *Gemini* astronauts are to perform outside the capsule. Two approaches are under study for the system—a fully self-contained system and an on-board system to support the astronaut through an umbilical.

INDUSTRY

Aerojet Develops Advanced Booster Engine

Air Force is funding development of a revolutionary liquid rocket engine concept by Aerojet-General Corp. The engine family uses storable propellants and is based on advances in liquid-engine hardware technology. A higher chamber pressure is the key to the powerplant's performance and the system is amenable to high-energy propellants. Whether this is a similar engine recently described by Dept. of Defense as having performance greater than NASA's cryogenic M-1 engine is not yet known.

LSI Wins Marshall Test Area Contract

Lear-Siegler Inc. has been awarded an estimated $4-million contract for installation of new technical systems and modification of present systems at Marshall Space Flight Center's east test area. Both stages of *Saturn IB* will be tested and vibration tests of *Saturn V* will be conducted.

Walt Williams Sought by Aerospace Corp.

Aerospace Corp. has offered Walter Williams, deputy associate administrator for NASA manned space flight operations, the post of vice president of its manned systems division. Williams reportedly is favorably disposed toward the offer—but the U.S. astronaut team and other space agency officials are trying to persuade him to remain with Projects *Gemini* and *Apollo*.

INTERNATIONAL

Hawker Siddeley Signs Pact with Matra

The guided weapons and rocket division of Britain's Hawker Siddeley Group, Hawker Siddeley Dynamics, has signed an agreement with France's Engins Matra for co-operation on all aspects of research, development and production in the electronics, missiles and space research fields.

Swedish Firms To Study ESRO Satellite

Preliminary studies for the first European Space Research Organization (ESRO) satellite will be carried out by three Swedish firms—SAAB, ASEA and LME. Launch is scheduled for September, 1967, from Pacific Missile Range aboard a *Scout* booster.

The Missile/Space Week

ERC Gets Final Approval

The Senate Aeronautics and Space Sciences Committee voted not to bar NASA's plans for an Electronics Research Center to be located in Boston.

The 10-to-4 vote cleared the way for the center, which earlier was approved by an 18 to 13 vote in the House Science and Astronautics Committee.

The Advanced Research and Technology Subcommittee of the House group cut out FY 1965 construction funds for the center, but this was expected to be overruled by the full committee in the light of its earlier approval. Vote in the subcommittee was 5 to 3, with Chairman Kenneth Hechler (D-W.Va.) voting against the reduction.

Advanced Rockets Pact Let

NASA has selected Lockheed Missiles and Space Co., Sunnyvale, Calif., to develop advanced technology for large nuclear and chemical rockets.

The contract—worth $1.5 million for seven months—will continue and keep up to date certain research begun as a part of the RIFT vehicle project.

Principal areas of activity will be insulation development, cryogenic testing, structural development, application of RIFT technology to *Saturn* stages and documentation of pertinent technology for future use.

USSR Offers Aid to Astronauts

The Soviet Union has submitted to the United Nations legal committee on the peaceful uses of outer space a treaty draft that would provide aid to astronauts in distress and to the launchers of downed spacecraft.

It differs from a recent U.S. proposal on that subject in that it would authorize the country that launched a downed spacecraft to conduct unassisted searches for it on the high seas.

It also imposes two conditions on the return of a strayed spacecraft: it must have been launched "for the purposes of peaceful exploration and use of outer space;" and the launching must have been previously announced.

The Russian draft is similar to that of the U.S., however, in that it suggests employing "every means at the disposal" of a state in assisting astronauts in distress.

Shots of the Week

A land-launched *Polaris A3* failed to reach its Atlantic Missile Range target from Cape Kennedy Mar. 11 when the second stage veered off course shortly after separation. The Navy reported that most test objectives were met, however.

- The Air Force on Mar. 11 launched from Point Arguello, Calif., a secret satellite aboard an *Atlas-Agena* vehicle.

Bullpup B Engines Shipped

The first production engines for the *Bullpup-B* air-to-surface missile are being received by the Navy this week only six months after Thiokol Chemical Corp.'s Reaction Motors Div. received the production order.

The LR62 storable-fueled units are loaded at RMD's Denville, N.J., production plant and shipped in a ready-to-fire condition. The firm will complete shifting the LR62 production lines from Denville to Rockaway, N.J., early this spring.

NASA, DOD Going to Fair

NASA and the Dept. of Defense will provide a million-dollar display of rockets and spacecraft at the New York World's Fair, opening next month.

Headliner for the exhibit in the fair's Space Park will be a full-scale "boattail" section of the *Saturn V*, standing 85 ft. high. A *Titan II-Gemini* combination will be on view in a launch configuration.

Also on display will be full-scale models of the Lunar Excursion Module and *Gemini* capsule, and the actual *Mercury* capsule used by Scott Carpenter.

Titan III Booster at Edwards

The first 40-ton segments of United Technology Center's 120-in. solid booster are being unloaded at Edwards AFB this week.

The flight-weight *Titan III* boosters will go through firings in the Mohave Desert complex this spring in the second phase of the static test program scheduled for the strap-on million-lb.-thrust boosters. The segments are being shipped from Coyote, Calif., in air conditioned steel containers aboard 48-wheel truck-trailer rigs. Transport time is three days.

Later this year the first of the segments will be shipped via rail to Cape Kennedy, Fla.

Another Atlas Explodes

The third *Atlas* in less than a year—and second in the last month (M/R, Feb. 24, P. 11)—exploded in a silo at Walker AFB, N.M., Mar. 9.

In both the recent instances, the *Atlas F* missiles had been undergoing training exercises at the time of blast. Neither had a warhead attached.

Both blasts happened while the missiles were being hoisted by an elevator. Reports that the malfunctions were related to LOX "topping off" instrumentation or procedure have not been confirmed or denied by the Air Force.

Cook Wins AF Contract

Cook Electric Co.'s Tech-Center Div., Morton Grove, Ill., has been awarded a $600,000 Air Force contract for development of an air-launched recoverable rocket system. To be used for transporting scientific payloads to high altitudes, it will employ a modified *Genie* missile as the probe vehicle.

Second phase of the program calls for development of systems to separate the payload from the carrier, stabilize the payload for proper functioning, control its descent and provide for air-snatch recovery. The modified *Genies* will be capable of either supersonic or subsonic launch.

The program is a follow-on to the *Jason* sounding rockets, used in high-altitude probes to measure space radiation and nuclear radiation levels. Deliveries already have begun under the Cook contract.

Genie was selected for two reasons: 1) it is an operational system; 2) it is an air-launched vehicle and as such provides advantages over ground-launched high-altitude probes.

Nike Move Blocked

A proposal to shift more than 20 *Nike-Hercules* batteries from various Strategic Air Command bases to hardened sites reportedly was refused by the House Armed Services Committee.

The action, reportedly to have cost $45 million, was part of a $101-million cut suffered by the Army in the now $1.6 billion Military construction Authorization Bill reported out by the committee. Total cuts were $248.8 million.

Floor action is expected sometime this week.

Final action was taken last week on the Military Authorization Bill (M/R, Mar. 2, p. 16) for procurement and research, development, test and evaluation, with conferees from the House and Senate Armed Services Committee agreeing on a total bill of $16.98 billion.

Senate action cutting the *Mobile Medium Range Ballistic Missile (MMRBM)* back from $110 million to $40 million to be applied only to the Stellar Inertial Guidance system was accepted by the House.

Conferees agreed to halve the $125 million difference between the two houses. Final bill is $208 million less than DOD requested, and $1.3 billion less than last year.

Wilson Snubs Polaris

Britain's Labor Party leader Harold Wilson has reaffirmed that his party would cancel that country's *Polaris* agreement with the U.S. if the Laborites win the general election this year.

In a television interview, Wilson said, "We have made it clear from 1961 onwards that Britain will cease this pretense of being a nuclear power."

The statement is interpreted as a firmer rejection of the Dec., 1962, Nassau agreement, which substituted the *Polaris* for the cancelled *Skybolt* in Britain's defense future, than any previous remark on the part of a Labor spokesman.

CORRECTION

The Univac Division of Sperry Rand Corp. was erroneously listed in the Mar. 2 issue, p. 17, as a member both of the Sperry Gyroscope-Kollsman Corp. and the TRW Space Technology Laboratories-General Precision, Inc. teams of program definition phase contractors for the Standardized Space Guidance System. Univac is teamed only with the latter group.

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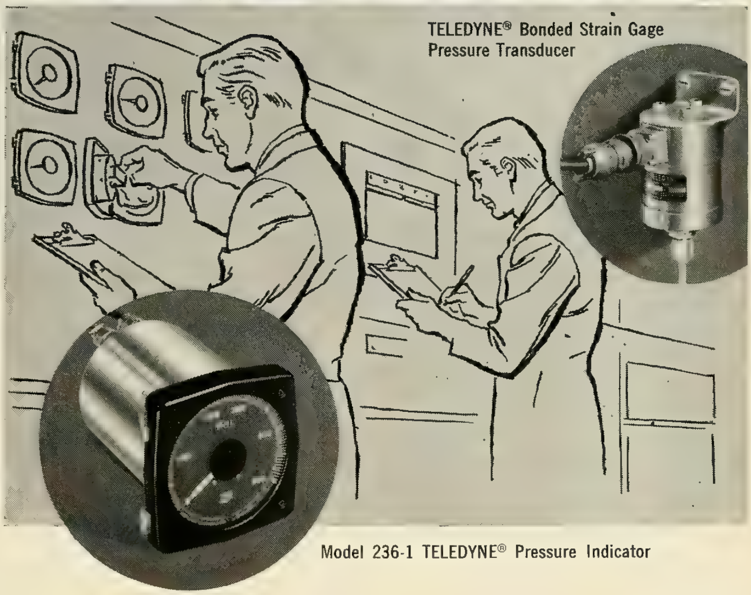
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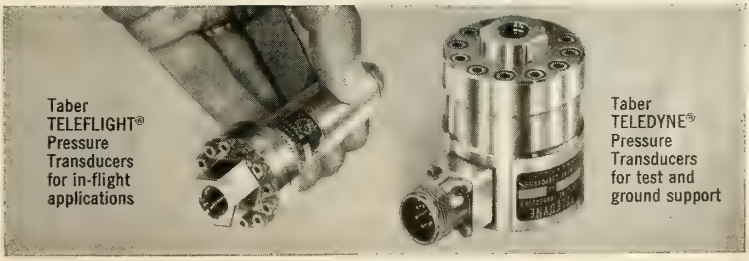
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Budget cutting blamed . . .

Saturn V Slippage Is Certain

Analysis of detailed program schedule indicates first manned flight in late '68; lunar landing this decade looks impossible

by Hal Taylor

HUNTSVILLE, ALA.—Early slippage in the *Saturn V* booster program probably will put off its first launch until mid-1967 and its first manned flight until late 1968.

This will put the U.S. goal of landing a man on the Moon by the end of this decade almost out of the question.

The original schedule called for first launch of *Saturn V* in the second quarter of 1966.

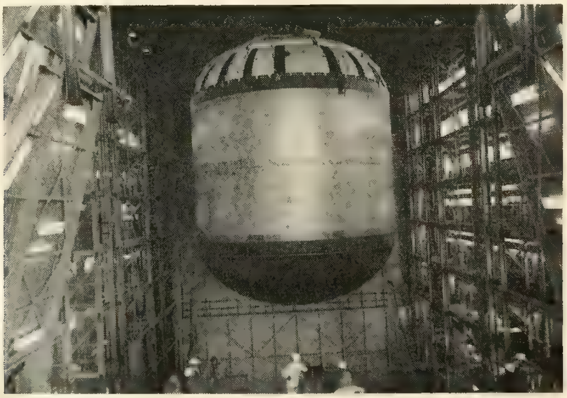
The latest schedule calls for shipment of the first 7.5-million-lb.-thrust S-IC first stage to Cape Kennedy in July, 1966. However, the first S-II second stage will not reach the Cape until the last quarter of the year. Since six months is required to mate and check out the vehicle, it is now certain that the first launch will not be made until mid-1967.

The target for a manned flight is also slipping.

Despite hopes in some official NASA quarters that the first manned mission could be flown on the third flight of the big rocket, officials at NASA's Marshall Space Flight Center, which directs the *Saturn* program, believe that shooting for a manned flight on the fifth is far more realistic.

It's believed that the *Saturn V* will not be able to lift the *Apollo* spacecraft weight of 90,000 lbs. until the fifth flight because of heavy testing equipment on the earlier flights.

- **Overly ambitious schedule**—The most optimistic schedule calls for a *Saturn* launch every three months. Experience in past flight programs makes this look dubious. For example, in the *Saturn I* project, five flights were made over a period of 27 months, or one every five months. In the *Mercury* flight series, Earth-orbital launches were made about once every seven months.



SATURN V first-stage fuel tank moves into hydrostatic testing.

Based on that history, five *Saturn V* flights will probably require a minimum of two years to complete, putting the first manned mission into late 1968 or possibly even 1969.

Prime reason for slippage in *Saturn V* apparently is Congressional cuts in funding. Officials at Marshall said that no major technical problem has delayed the project, but there have been a lot of minor wrinkles which had to be ironed out.

Part of the slippage is also attributable to the combustion instability that occurred in the first stage's 1.5-million-lb.-thrust *Saturn* F-1 engine.

There also have been delays in delivery of the first-stage components, but this has been blamed on the under-capacity of available tools at the Michoud launch vehicle facility.

The Boeing Co. is prime contractor for the first stage, which is being built at Michoud. Marshall is developing three test models and the first two flight stages.

The S-IC first stage is 33 ft. in diameter and 138 ft. high. The S-II second stage—being developed by North American Aviation, Inc.—is 33 ft. in diameter and 82 ft. high. The S-IVB third stage—with Douglas Aircraft Co. as prime contractor—is 22 ft. in diameter and 59 ft. high.

- **Plan VII details**—Officials here recently completed Plan VII, outlining the test and Cape Kennedy delivery schedule for the first stage of the *Saturn V*. Some slippage already is creeping in.

Engineers had expected to hold the first static-firing of the booster late this year. The static-test vehicle will not be delivered, however, until Nov. 15. This will put off the first static test until February, 1965.

The F-1 engines for the vehicle—named the S-IC-T—are to be delivered starting in August, 1964. Two engines also will be delivered in September, October and November.

The first static test will be run with nly one engine. Then the two outboard ngines will be added. By March 1, 1965, engineers hope to make the first ull five-engine static firing. Testing of he static vehicle will last about one ear.

Assembly of the first flight stage will egin in June, 1964, and last about 13½ nonths. Structural components are cheduled to be delivered to Marshall rom Michoud in April and May of his year. Propulsion components will e delivered in June or July and intrumentation in February-March, 1965.

In-plant checkout and modification vill begin at Marshall in August, 1965, nd will take about five months. Aceptance firing in the test stand will egin in January, 1965, and last three nonths. Refurbishment and checkout vill then be undertaken prior to shipnent of the booster to Cape Kennedy in uly, 1966.

● **Responsibilities outlined**—Under lan VII, Marshall is responsible for uilding the static-test vehicle, the strucural test model, a test fuel tank and the irst two booster flight stages.

Boeing is responsible for two test ehicles—S-IC-D, a dynamic test model, nd S-IC-F, which will be used to heck out facilities at Cape Kennedy.

Boeing will also build eight flight tages at Michoud. Fabrication of the irst one, SIC-3, will begin in February, 1965. It is slated for delivery to Cape Kennedy in March, 1967. Delivery of the other seven are scheduled to follow at three-month intervals through July, 1968.

Marshall engineers are currently engaged in a sharp weight-shaving program to keep the first stage below its specification weight of 293,670 lbs. Its current projected weight is 292,043 lbs., primarily because of various changes that trimmed 5,000 lbs. from the vehicle.

The lighter vehicle was achieved by redesigning the LOX tunnel bellows, which cut 275 lbs.; revision of the LOX tunnel ring, 100 lbs.; tapering the skin for the intertank, 132 lbs.; reduced weight of the fuel tank "Y" rings by 1,500 lbs.; reduced weight of the machine pockets in the LOX tank "Y" ring, 1,680 lbs.; tapering fuel tank panels, 120 lbs.; and tapering the LOX tank skin panels, 388 lbs.

While a definite fix on the *Saturn V's* weight will not be available until a flight vehicle is built, officials here declare that it will meet its specified payload capability of 90,000 lbs.

● **S-II weight critical**—One *Saturn V* official told MISSILES AND ROCKETS that there is always a struggle between weight and performance. "I'm positive we will meet our payload capability unless we run into orbital problems," the official said.

He said that the S-II stage is the critical item because it is a cluster of five liquid hydrogen J-2 engines using a million pounds of propellant.

He said there have been increases in weight of the hydrogen tank, but these are being offset by other weight reductions.

He admitted that Marshall has prepared a list of critical items for which it wants NASA headquarters to approve backup systems.

He declined to reveal what specific systems were involved until NASA headquarters had passed on them. He said this would take several more weeks.

M. V. Urlaub, first-stage program manager at Marshall, cited the S-IC project as a true joint venture between government and industry.

"It is a parallel program and one can't go on without the other. If we miss a milestone, this will force Boeing to miss one," Urlaub said.

As an example, he cited the S-IC-T static-test vehicle which is being assembled at Marshall. The whole project, he continued, depends on a satisfactory test program. After the test program is completed at Marshall, the stage will be shipped to the Mississippi Test Facility to checkout and test stands there before the arrival of the first Boeing-built stages. Thus, any delay in the test program at Marshall probably will delay the MTO and Boeing programs. ■

Stringent Missile Reliability Test Set

THE DEFENSE DEPT. plans to xpend 10% of each type of missile in e U.S. strategic retaliatory arsenal in perational tests over the next 18 onths. This extremely high firing rate also programmed over the span of e five-year program package presented Congress with the FY '65 budget.

At presently planned force levels, is would mean that approximately 100 *inuteman*, 20 *Polaris A2* and 45 *Poris A3* as well as lesser numbers of *itan* missiles would be fired each year er the next five years to ensure the liability and dependability of U.S. rategic forces.

This accelerated launch schedule, alough programmed for the entire five ears, is not expected to be necessary. s experience and statistical data is acmulated, Defense officials expect that e percentage of the force expended ch year would drop closer to 5%.

This annual program will be concted from Vandenberg AFB (*Mineman*) and Cape Kennedy (*Polaris*).

● **Minuteman program**—Operanal firings of the *Minuteman* will inlve removing the operational missile from its silo and emplacing it in a silo at Vandenberg. Following this artificial operation, the test would be conducted as a complete operational readiness test with Air Force launch-control personnel responsible for the launch.

Although a considerable number of *Minuteman I* firings have been conducted, DOD has not included a large percentage of these in the statistical sample for reliability calculations. The reason for excluding these firings is that either the missile has changed or the conditions were not representative of a "no-notice" operational launch.

Consequently, further flight testing of the *Minuteman IB* (a distinction to differentiate these missiles from the lesser capability Malmstrom AFB missiles), is planned over the next year. DOD has, in fact, considered the possibility of over-flying parts of the U.S. to add as much realism as possible to the operational test. So far this possibility has been rejected.

Over the next 12 months, more than 40 *Minuteman IB* missiles will be fired. Following this, large-scale operational testing of *Minuteman II* will begin.

● **Polaris program**—Operational testing of *Polaris* is somewhat simplified by the fact that a sufficient number of *A2* missiles have been fired to provide a representative statistical sample. Thus there is little question that the *A2* can meet its reliability goals. Further operational testing, therefore, will concentrate on crew readiness and equipment suitability.

The *A3* missile, however, does not enjoy this same degree of confidence. Expected to become operational in August, the *A3* will begin its operational readiness tests approximately eight months later.

So far, according to Defense officials, the *A3* has been following the reliability pattern set by the *A2* and, except for development problems with the second stage automatic shutoff mechanism, is proving to be a dependable system even in development.

However, DOD plans call for operational firings from submerged submarines off the coast of Cape Kennedy. These missiles would be fired as the submarines came off-station. ■

Clears House committee . . .

NASA Budget Little Damaged So Far

by Heather M. David

THE HOUSE Science and Astronautics Committee left the NASA FY 1965 budget in relatively good shape, cutting only about $100 million, to leave more than $5.2 billion.

The large orbiting observatories took the brunt of the trimming in the research and development category.

All committee members interviewed said they did not feel that the $5.2-billion level would in any way injure the effort to land a man on the Moon within the decade. Administrator James E. Webb has told Congress repeatedly that both the supplemental and the full authorization will have to be appropriated if the goal is to be met.

Manned spaceflight programs, which last year took a heavy beating, with several hundred million cut, this year escaped serious injury with only a $3.9-million reduction in advanced missions. *Apollo* and *Gemini* got unanimous approval of the full committee and subcommittee.

The cut in advanced missions brought that fund back to the 1964 level of $22.1 million, on the basis that NASA had not made a substantial case for increasing this over the amount it had budgeted for the previous year.

- **OSO**—Rep. Joseph E. Karth (D-Minn.), chairman of the Space Sciences and Applications Subcommittee, told Missiles and Rockets orbiting observatories were questioned "because it appears that they have become ambitious compared to previous years."

However, he added, the committee's actions amount to deferrals based on the belief that some activities may ultimately prove to be unnecessary, and in some cases on a belief that requests were premature.

The subcommittee pointed out that NASA's launch schedule for the first *Orbiting Solar Observatory* has already slipped by a year, and that the projected gap between later launches had grown from six months to nine months. Even this, it said, was "overly ambitious," and one launch per year would be more realistic. In addition, the subcommittee felt that a better-than-nine-month lifetime could be expected.

In view of the stretched-out schedule and some admitted overlap with the *Advanced Orbiting Solar Observatory,* the committee recommended that NASA defer its plans for the last three spacecraft of the eight in the program request. Thus, it cut $2.5 million from *OSO* funds.

- **OGO**—The same reasoning was applied to the *Orbiting Geophysical Observatory,* which NASA has scheduled for two launches per year. The subcommittee felt that one would make more sense. It cut $6.5 million from *OGO* funds, claiming it would be "unrealistic to provide funds for activities which would take place from six to eight years from the present date."
- **OAO**—The *Orbiting Astronomical Observatory,* which NASA had planned to launch at the rate of one a year starting in calendar year 1965, got similar treatment. Seven million dollars of $8.5 million sought for the last two (of five) spacecraft was "deferred" because some evaluation of the program might be needed after one finally was launched.

The subcommittee said the first launch already has slipped two years, and that, while recognizing the interest of the scientific community, "there appears to be no over-riding urgency in pursuing these investigations."

- **Surveyor**—According to the subcommittee, NASA has already started fabrication of seven *Surveyors* and plans to contract for two more, all of which will weigh 2,100 lbs. However, the Space Sciences Subcommittee questioned the wisdom of having the two additional flights of "this severely limited spacecraft."

Also, nine launches in less than two years struck the group as being too optimistic, especially considering the use of an "unproven launch vehicle, the *Centaur.*" Since the FLOXed *Atlas-Centaur* is to be phased into the program midway, the group felt that the last two probably would overlap into this era, when the spacecraft would be redesigned at the 2,500-lb. weight. Thus, $12.3 million was cut for the 2,100-lb. spacecrafts #8 and #9.

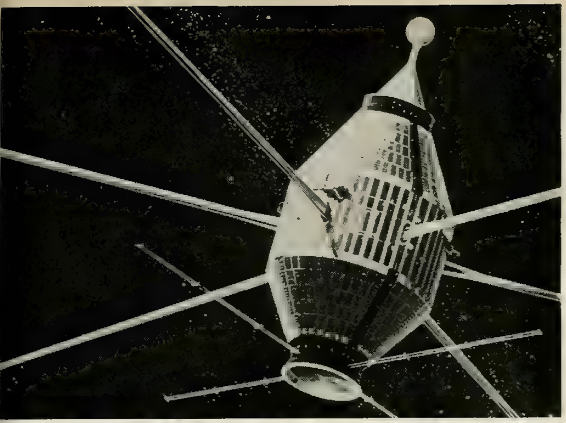
- **Lunar Orbiter**—The subcommittee cut a $5-million fund for an added block of five *Lunar Orbiters,* which has not received NASA program approval. The five authorized spacecraft are themselves two-and-one-half years away, the subcommittee pointed out, and the need for the second block was questioned in view of both *Ranger* and *Surveyor-Lander* objectives.
- **Applications**—All communications, meteorological and other applications programs were approved as requested, except for a $1.2-million fund proposed for "various economic considerations." The group directed that NASA "undertake research only in those areas clearly within its jurisdiction."
- **Launch vehicles**—While no funding cuts were made in the launch vehicle category, Karth's subcommittee voiced concern over the fact that funds have been overestimated by as much as 30-50%, then often not spent because of program delays.
- **Advanced Research**—The Advanced Research and Technology Subcommittee headed by Rep. Ken Hechler (D-W.Va.) was expected to add cuts of about $20 million, or roughly 6% of the amount handled.
- **Facilities**—Biggest bite in construction requests was taken by the Manned Spaceflight Subcommittee, which levied a 10% reduction across the board. Chairman Olin Teague (D-Tex.) said that NASA should be able to accomplish its work at about the same rate as the industrial firms constructing similar facilities.

This amounted to $22.5 million. A small slice of $147,000 was taken by the Space Sciences and Applications request, to be applied mostly in preliminary design work.

The Manned Spaceflight Subcommittee also levied an across-the-board cut of 5% in administrative operations, amounting to $15,228,500, on the basis that it did not feel that NASA had fully justified all its requests for equipment, supplies and "other services."

Total Manned Spaceflight cut is thus $41.6 million; Space Sciences and Applications lost $34.5 million; and $20 million is expected to be paved from Advanced Research and Technology.

- **Supplemental**—The $141 million requested by NASA for supplemental FY '64 funds remains in limbo in the Independent Offices Subcommittee of the House Appropriations Committee, presumably not be acted upon until the FY '65 bill is considered (M/R, March 2, p. 16). ■



"TOPSI" SATELLITE will obtain precise data on electron density distribution at the top of the ionosphere.

This week . . .

NASA Satellites To Make Detailed Ionosphere Study

NASA THIS WEEK is expected to launch two unmanned scientific satellites to make detailed studies of the Earth's ionosphere.

A 120-lb. *Beacon Explorer* (formerly *S-66*), boosted by a *Delta* vehicle, is scheduled to be launched no earlier than Mar. 17.

The satellite will broadcast data on the ionosphere to more than 33 countries and will also serve as the test bed for the first laser satellite experiment ever attempted.

A 97-lb. satellite, formerly *S-48*, and now nicknamed *"Topsi"* (Topside Sounder, Ionosphere) is slated for launch during the week of Mar. 16 to explore irregularities in the ionosphere and provide a better understanding of its F-2 region.

- **Beacon signals not coded**—The *Beacon Explorer* makes the extensive international scientific effort possible because it transmits uncoded radio signals. Most satellites send information by coded telemetry to a limited number of very specialized stations.

The uncoded radio signals are transmitted by the *Beacon Explorer* at wavelengths that cause changes in the characteristics of the signals as they pass through the ionosphere. By studying the nature of the radio signals as they are received on the ground, scientists throughout the world can participate in studying the ionosphere.

The *Beacon Explorer,* in its 120-mi. circular orbit, will also carry an electron probe experiment to measure electron densities and temperatures in the immediate vicinity of its orbit. Information obtained from this experiment will be sent by coded telemetry to ground stations of the NASA Space Tracking and Data Acquisition Network (STADAN).

In addition to the major ionosphere experiments, the *Beacon Explorer* will also serve as a test for a laser device located near Wallops Island, Va.

The NASA station will direct a beam of light toward glass reflectors mounted on the satellite as it passes over the eastern United States near the island. The laser beam, when it strikes the reflectors, will be returned to the source and precise measurements of the satellite's position in space can be calculated.

If the test is successful, it will not only provide the most precise orbital measurements to date, but will also furnish a new tool for the science of geodesy.

Ionosphere satellites fall into three general types, depending upon their assigned tasks. The first type, called direct measurements explorer, is designed to measure in detail the characteristics of both positively charged particles (ions) and negatively charged particles (electrons) in the ionosphere.

The second type of ionosphere satellite, called topside sounders, transmits radio signals of varying wavelengths, which are reflected from the top side of the ionosphere with the echo being received back at the satellite.

- **"Topsi" details**—*"Topsi,"* an example of the second type, was designed and built by the Airborne Instruments Laboratory of Cutler-Hammer, Inc. An ion mass spectrometer experiment was contributed by scientists at University College, London.

The 97-lb. satellite is conical, shaped something like a bottom-heavy duckpin. The main section is 26 in. in diameter and 32½ in. high. Mounted at the top is a ball-shaped ion mass spectrometer 4 in. in diameter. This mass spectrometer is at the end of a 10-in. tapered boom, giving the satellite an overall length of 46½ in. Power is provided by nickel-cadmium storage batteries, which are supplied by 2,400 solar cells mounted around the side of the satellite.

The name *"Topsi"* was coined by the National Bureau of Standards. The Bureau's Central Radio Propagation Laboratory, Boulder, Colo., designed the experiments the topside sounder will carry.

Topsi's ion mass spectrometer was "borrowed" from the British-designed *UK-1*, or *Ariel,* international ionospheric satellite.

The Airborne Instruments Lab-built satellite will complement and capitalize on data that have been supplied by the civilian Canadian Defense Research Board's *Alouette* topside sounder. *Alouette* was launched by NASA Sept. 29, 1962, and is generally considered one of the most successful scientific satellites ever orbited. It is still transmitting.

The *Beacon Explorer,* in effect, represents a third type of ionosphere satellite. Its radio transmissions are made at wavelengths that penetrate through the ionosphere to the ground. Thus, it will transmit "raw" cross-section data on the structure on both the top and bottom sides (without altitude discrimination) of the ionosphere directly to the network of ground stations.

- **Beacon shape**—The *Beacon Explorer* is an octagonal-shaped satellite with four solar panels extending from its sides like the blades of a windmill.

The shell is 18 in. in diameter and 12 in. high. It is made of honeycomb nylon and glass fiber. Protruding from its top and bottom are the short antenna-like poles used for the electron probe experiment.

The solar panels are covered with solar cells to convert energy from the Sun into electricity to charge nickel-cadmium batteries that provide the power to operate the satellite. These panels are 10 in. wide and 5½ ft. long. ■

With some changes . . .

Weather Bureau Prepares To Buy Tiros-type Craft

CONTRACTING is expected to begin this summer on the new *Tiros* Operational System (TOS) funded by the Weather Bureau.

Dave Johnson, who will succeed Dr. S. Fred Singer as director of the National Weather Satellite Center next month, says the initial contract may call for four spacecraft. Funds will be transferred to NASA during the second quarter to facilitate negotiations, he told MISSILES AND ROCKETS.

Although NASA will be the contracting agency and provide technical management, Weather Bureau officials will sit in on all proceedings and will approve the final choice.

• **Modifications**—The new *Tiros*-type spacecraft will be much like the *Tiros I*, which will be launched next by NASA, and is expected to cost about the same as those in the current series. However, these differences are being considered:

—*Cameras*—The two agencies are looking at the possibility of combining the highly successful Automatic Picture Transmission (APT) system with the Advanced Vidicon Camera System (AVCS). This could be done two ways: 1) by putting a recorder on the APT system, or 2) taking the AVCS and adding a recorder with variable readout speed—actually developing an advanced APT. Both these approaches are being worked on—the latter being more favorable since the resolution would be much greater. Each satellite would be equipped with two camera systems.

—*Infrared*—Although the cartwheel configuration presents problems in IR sensing, several simple IR systems are being studied which could provide gross information. One would give resolution of only 200-300 miles, compared to *Tiros's* present 30-50 mile system, but data would still be valuable, Weather Bureau officials said.

—*Orbit*—NASA is studying the possibility of using a *Thrust-Augmented Delta,* which would enable it to launch the *Tiros* satellite to 700-mile, near-polar circular orbit. According to meteorological satellite chief Dr. Morris Tepper, this would allow one of two cameras, which will be placed on the sides of the "wheel" and canted at an angle of 26°, to get an overlapping track as it moves over the Earth. Thus, if one camera fails, and in almost every case one of the two *Tiros* cameras has failed early in its lifetime, the other still gets the complete picture.

The basic cartwheel configuration will be tested by NASA in its R&D series, four of which probably will be launched before the TOS system goes into effect. According to Tepper, a wheel-configured "J" is expected to be launched into a low inclined eccentric orbit, about 300 miles perigee and 3,000 miles apogee, with TV and IR sensors. The next, "K," will go into very eccentric inclined orbit, at 22,000 miles apogee. This will enable the camera to watch one portion of the Earth for about two or three hours. NASA's "L" may also be wheel-configured, in polar orbit, although this order may change.

Without the souped-up *Delta,* altitude will be about 400 miles in the polar, circular orbit.

• **Cameras fired**—Two systems for triggering the cameras so that in their 10 rpm cartwheel rotation they fire only when pointed at the Earth are being discussed, Tepper said. One will be self-computing, probably with an IR horizon sensor which would trigger the camera, the other spin-synchronized with a possible override from the ground if the picture started going askew.

As the cartwheel satellite now is designed, it has a coil to maintain the horizontal rotational axis. Small propulsion jets are now programmed to increase or decrease the spin rate. However, Tepper said, it may be possible to utilize a similar coil, horizontally wrapped, to maintain spin rate at 10 ±½ rpm.

A big effort will also be made to increase subsystem cross-scrapping, Tepper said. Although it will not be possible throughout the system, he said, a push is on to achieve integrated redundancy in which switches can be made at a much lower level than has been done. This may add some weight, he said, but not a significant amount.

In fact, if the plan for the *Thrust-Augmented Delta* is approved, a larger and heavier *Tiros* could be accommodated. However, the limiting factor is the amount of power attainable by the solar cell paddles. Tepper also disclosed that some thought is being given to making conically shaped surfaces to increase this potential, although this is far in the future.

• **Process gradual**—The evolution into the new operational system will be a gradual one, Dave Johnson said. Of the three remaining Weather Bureau *Tiroses* purchased under the original agreement, two probably will be cartwheel and will begin to blend in the improved sensors.

The new system probably will be initiated in 1965, Johnson said. As many as four satellites could be launched a year, if present lifetime averages hold out, since two will be in orbit at once. Launches will be made from Atlantic Missile Range.

A number of advanced sensor systems are still being studied at the Satellite Laboratory, Johnson reported. Infrared still ranks as one of the great promises of the future, he said, and grows more useful in meteorological studies. The laboratory also is investigating a medium-resolution IR radiometer which could give data on cloudtop attitude, and from which vertical temperature profiles could be inferred.

Sensor work is also going toward CO_2 detection, and spherics measurement.

Some of these sensors may be offered for testing on *Nimbus,* Johnson said, although the Weather Bureau still does not feel that the *Nimbus* satellite as it now exists is economical for operational use.

• **Operational system**—Johnson estimated that a reasonable annual operating cost would be from $35 to $40 million. For this, he said, the Bureau would expect to get both infrared and photographs, with complete coverage four times a day. Long life would be essential, he said.

While the synchronous satellite has "some very attractive advantages," he said, it would not give polar coverage, vertical profiles of temperature, or certain other information, because of its great altitude. ■

Publication before mid-year . . .

AFSC Preparing Tech War Plan

Document will include findings of Project Forecast report, become primary guide for allocating Command's resources

A TECHNOLOGICAL War Plan—expected to become the primary basis for allocating resources and establishing priorities within the Air Force Systems Command—is in the final stages of preparation at AFSC Headquarters, Andrews AFB, Md.

The document, which was being shaped during much of 1963, has already undergone one major revision to incorporate the findings of the still-classified Project Forecast report.

Termed "basic" to AFSC's planning concept, the Technological War Plan (TWP) will be the source of guidance for plotting future courses of action, justifying resources and providing long-term cohesiveness and continuity of effort. The plan is expected to be published before the middle of the year.

• **A new pattern**—Traditionally, individual components have been developed as improvements in separate technologies and then welded together into a weapons system as the need arises. However, this does not necessarily ensure that components critically needed for a weapons system will be available when they are needed.

Through analyses of the capabilities of current forces, the potential threat, the anticipated environment and new technological advances, the Tech War Plan would seek to guide the development efforts of AFSC into militarily productive areas.

This "planned innovation," in addition to providing a sound analytical basis for development planning, is intended to permit savings in both development time and cost.

Basically, the TWP will present a matrix of system objectives and technical efforts required to achieve those objectives. Within the matrix, the relative importance of the technical effort will be called out by color codes. For example, to meet strategic objectives, technical effort in flexible structures might be termed "critical" while efforts in composite materials would be merely "supporting" these objectives.

Areas of technology which have not yet been related to specific missions but which promise important benefits in the future would be called out within the matrix as having "high potential." Examples of two such areas might be work on nuclear gyros and on self-repairing circuits.

Closely related to the mission objectives/technical effort matrices would be cost estimates of the resources required to achieve these objectives.

• **AFSC annual report**—In issuing its annual report for 1963, AFSC listed its major contributions to the defense posture over the past 12 months:

—Delivery of two wings of *Minuteman* and five flights of a third wing to the Strategic Air Command, as well as six squadrons of *Titan II;*

—First flight test of a communication system to penetrate the plasma sheath surrounding vehicles during reentry;

—Development of an air-to-air infrared communication system that is difficult to jam, intercept or detect;

—Completion of *Hound Dog* and *Falcon* test programs;

—Bringing the third Ballistic Missile Early Warning System (BMEWS) site at Fylingdales Moor, England, to operational status with formal turnover to North American Air Defense Command planned for 1964.

One of the major problems facing Systems Command, however, is the lack of modern technical facilities.

"Although some new projects were approved," AFSC Commander Gen. Bernard A. Schriever points out in his preface to the annual report, "1963 was a disappointing year in our program to expand and modernize the Air Force technological facilities base.

"Additional new laboratory, simulation and instrumentation facilities will be required, however, if the Command is to adequately carry out assigned test and evaluation responsibilities."

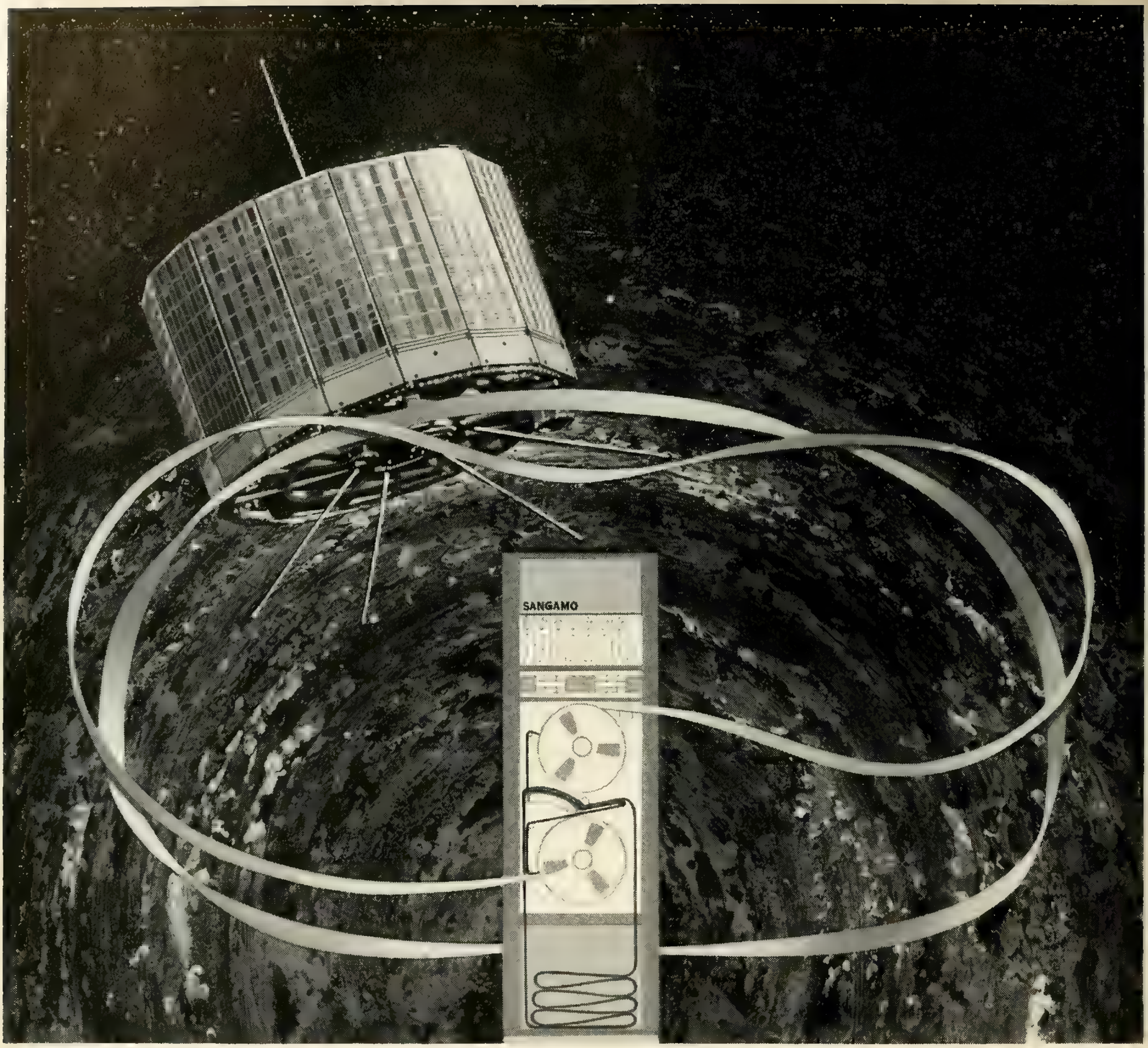
• **Management progress**—Major improvements were made over the past year in procurement through the reduction of the number of letter contracts outstanding and a drastic reduction of the number of cost-plus-fixed-fee contracts. Letter contracts were reduced by more than 50%—from approximately 250 with a value of about $1.8 billion to less than 100 with a value of $750 million. Incentive contracts and fixed price awards rose during the year from 31% to 52%, with an estimated savings to the government of $150 million.

Responding to the Defense Department's cost-reduction program, AFSC reported that $398 million in savings was realized in 1963. In addition, as part of the Command's Project Purse Strings, an additional $122 million was reported as cost reductions. This is not reportable under DOD's program.

• **Technical achievements**—One of the most significant advancements in technical progress made in 1963 was development of a new, high-temperature, high-flexural, easily machinable, oxidation-resistant graphite. Presumably a product of Materials Central at Wright-Patterson Air Force Base, Ohio, the material has an extremely low rate of oxidation at temperatures up to 3,500°F.

Additives, rather than the graphite itself, oxidize to form a protective layer that prevents further oxidation as critical temperatures are reached. The material is also self-sealing, re-forming to seal off any punctures in the coating caused by flying objects.

A low-frequency communications site—employing a 1,200-ft. transmitting antenna—was also installed and successfully tested at Hawes, Calif. Using a special modulation technique, the tests verified system design and provided the basis for acquisition of a complete low-frequency system. ■



Another Sangamo first in Magnetic Tape Flexibility

NOW THE SANGAMO 4700 HANDLES BOTH 1" AND ½" TAPE SIMULTANEOUSLY

Record or Reproduce either width without mechanical or electrical changes.

Make continuous loop dubs from original tapes on one recorder. Operating at your choice of 8 electrically-selected tape speeds, Sangamo 4700 now has an optional feature which allows you to handle two different tape widths at the same time. One width operates in reel-to-reel mode . . . the other width operates as a continuous loop.

Flexibility is unparalleled. Without time-consuming mechanical or electrical changes—without even changing heads or guides—the 4700 will handle ½″ or 1″ tape, either on reels or in a loop.

The Sangamo 4700 is unique in analog tape instrumentation. Its light mass capstan drive and unmatched servo speed control provide unsurpassed data accuracy in FM (DC to 20 KC) and Direct (300 to 300,000 cps) ranges.

Be sure to investigate the 4700 for general recording applications and the 480 time delay magnetic tape recorder/reproducer for auto- and cross-correlation applications. *See the 4700 and 480 at the IEEE Show, Booth 3107.*

SANGAMO ELECTRONIC SYSTEMS

ES64-1

SANGAMO ELECTRIC COMPANY
SPRINGFIELD, ILLINOIS

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Technical Countdown

ELECTRONICS

Sun Pumps AO Laser at Room Temperature

Neodymium-doped glass has been used (at 30°C), with the Sun as a pumping source, to achieve continuous laser action. Accomplished by American Optical Co. in its research facility at Southbridge, Mass., this is believed to be the first solar-radiation-pumped laser operation at room temperature. Working under an Air Force research program, researchers used a 2-ft.-diameter parabolic mirror and glass lenses to collect and concentrate solar energy onto a 2.8-mm. diameter spot. The 30 x 1-mm.-diameter laser, placed at the focal point, produced an output of 10 microwatts, the company claimed.

Albedo-Proof Sun Seeker Developed

A 2-lb. satellite sun-position indicator, developed by Bulova Watch Co. for Lockheed Missiles and Space Co., will operate on 0.2 watt and function for over one year in space, designers claim. The new device will be boom-extended to provide nearly complete spherical coverage. Designed for high radiation resistance, the unit is a multi-faced instrument provided with pinhole apertures on each facet for admitting solar radiation to photo-conductor cells within the structure. The design, said Bulova, solves the albedo problem (confusing solar radiations reflected from other bodies in the solar system).

IMCC Display TV To GPL

Philco Corp., prime contractor on the development of the Integrated Mission Control Center at Houston (M/R, July 8, 1963, p. 32) has selected the GPL Div. of General Precision, Inc., to supply 73 of its new precision 820 TV cameras for prime displays at the IMCC. Delivery is slated to start this year. The cameras have 675 lines of vertical resolution and 800 lines horizontal resolution.

Shipboard Satellite Display to be Tested

The Navy will test a computer-driven satellite display system later this year to see what role such equipment can play in shipboard operations. Data processing in the experimental Satellite Position Prediction and Display equipment (SPAD) is handled by a TRW 130 computer, which stores orbital data on 100 selected satellites. Orbits of any 10 of these can be generated on a map display with a wide range of time scales. Also, areas free from surveillance by spy satellites can be located rapidly. The satellites displayed are selected by country of origin and function: surveillance, communications, navigation, weather, scientific and unknown. Developed by the Naval Research Laboratories for the Bureau of Ships, the system has been designed as a versatile research tool rather than as production equipment, the Navy said.

Marshall Steps Up Atmospheric Studies

To study atmospheric jet streams (which can seriously affect rocket flights), Marshall Space Flight Center physicists recently launched 161 rawinsondes (meteorological balloons) during a 10-day period. Data were recorded, officials said, on four different high-altitude weather fronts. Part of an intensive measurement program in which over 1,000 balloons have been deployed to date from 31 measuring stations in the southeastern United States, the effort has obtained data up to 12 miles. Ultimately an atmospheric model will be developed for studying conditions for pre-launch monitoring and acoustical conditions related to static tests of large boosters.

ASTRONAUTICS

Space Studies Brought Down to Earth

Fundamentals of geology and geophysics have now been added to the NASA astronauts' training to prepare them for eventual lunar-surface exploration. The U.S. Geological Survey division of the Interior Dept. is assisting NASA in the program at the Manned Spacecraft Center in Houston. Fifty-eight hours of classroom instruction, plus field trips, will be included in the course, said DOI.

Auroral Echoes Received on S-Band

Four scientists at the Cornell Aeronautical Laboratory report in the January issue of the *Journal of Geophysical Research* on what they believe to be the first S-band reception of definitely established auroral echoes. The scientists say that strong auroral echoes were received on the CAL S-band research radar during the evening of Sept. 24, 1963. Strongest echo reported was 18 db above noise, which corresponds to a radar cross section of 10^{-2} m^2. Peak power level used during the observation was 20 megawatts and the pulse length was 7 microsecs. According to CAL, the short pulse, together with a half-power beamwidth of 0.4 degree, enabled a determination of spatial dimensions of the echoing regions to be made.

MATERIALS

Dyna-Soar Materials To Be Published

The results of one of the most intensive high-temperature materials development programs in history will be published by the Department of Defense as fallout from the defunct *Dyna-Soar* program. The report, which will cost DOD about $50,000.00, will cover both materials development and fabrication techniques involved in creating a manned, maneuverable re-entry vehicle.

Moly Bar Stock Line Extended

Climax Molybdenum Co. is extending its low-carbon arc-cast molybdenum metal product line to include bar stock from ⅛-in. to 4⅛-in. diameter while increasing ductility and impact resistance in these mill sizes. The guaranteed elongation values issued by the firm are a minimum elongation of 30% in 4d as compared to 20% for standard moly bars meeting the same hardness specifications and minimum tensile and yield strengths.

SPACE MEDICINE

Pure Oxygen Tests Delayed

The 30-day 100% oxygen exposure portion of a space cabin experiment at the School of Aerospace Medicine was temporarily delayed when a malfunction in a small electric blower motor occurred. The four subjects, who had already started the 100% oxygen breathing after a week of tests, remained in the cabin while repairs were made. The test is now scheduled to run throughout the month of March.

Submerged Transponders Would Fix Missile Impact Points

Ship-Tended Acoustic Relay system to consist of 5 to 7 transponders in 10-mile circle; to meet AF requirement

by Rex Pay

NORTH HOLLYWOOD, CALIF.—Acoustic bench marks on the ocean floor would give an accurate means of locating missile impact in the Ship-Tended Acoustic Relay (STAR) system proposed by Bendix-Pacific div. to meet the requirements of the Air Force Missile Test Center, Patrick AFB, Fla.

Following an oceanographic survey, five to seven transponders would be laid on the sea bed, around the periphery of a 10-mi.-dia. circle. As a missile enters the target circle, the noise generated as its kinetic energy is dissipated would be detected and relayed to a surface ship by means of sonar FM telemetry.

These signals would be recorded with missile-range timing signals.

Besides relaying the sound of the missile plunge, the transponders would respond to interrogation pulses from the attending ship, giving it a means of accurately fixing its position.

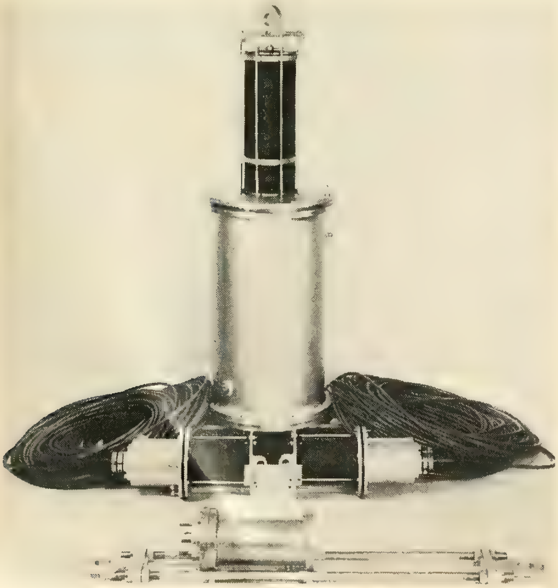
This allows the time for transmission from the transponder to the ship to be subtracted from the total reading.

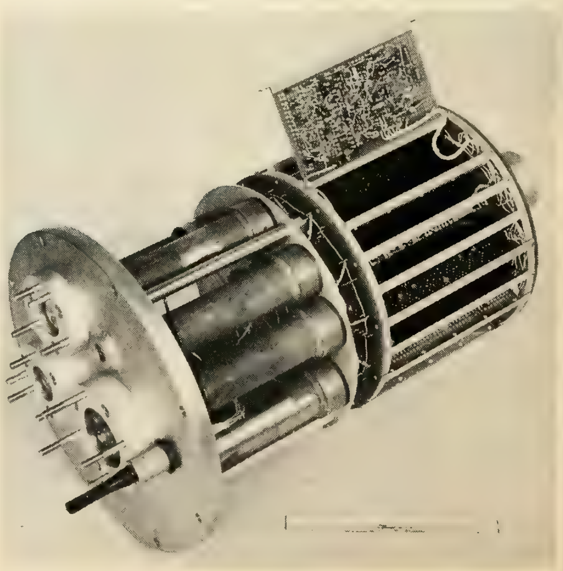
Chief errors to be expected in the system are uncertainty of the propagation velocity of sound and curvature of the ray path, the latter being very small.

- **Free of buoys**—Three transponders would be sufficient to measure the position of a simple noise source. Seven provide not only redundancy but also the capability of handling the multiple signals that can be expected if a missile breaks up into several parts.

One advantage of the system is that is does not rely on moored surface or subsurface buoys for position fixing. Surface buoys in the open ocean may

LEFT: Missile impact array unit, including hydrophones, transponder and associated cables. BELOW: STAR transponder with cover removed.





STAR BATTERY pack provides over one year of deep ocean penetration.

have a life as short as two weeks. Lack of knowledge about subsurface currents makes subsurface buoys something of an unknown quantity.

The circuits used are not contained within a pressure vessel but are subjected to the full pressure found at these depths.

Absence of a pressure vessel reduces weight and handling costs, and eliminates problems of cable sealing.

- **Test results**—Feasibility of the STAR system was demonstrated in Phase I tests in February, 1963, (M/R, Dec. 16, p. 25), at depths of 15,000 ft. A transponder net was operated successfully for slightly less than two months, under contract with AFMTC, Air Force Systems Command.

In the tests, carried out 90 miles northeast of the Bahamas, both navigation transponders and Sofar transponders were used. The Sofar transponders detected the explosion of gas bombs in the long-range Sofar channel at 4,000-ft. depth and relayed the sound by frequency-modulated sonar telemetry to an attendant vessel.

Frequency-modulated telemetry transmission from depths in excess of 15,000 ft. was provided in the 9-kc region over ranges greater than 15 miles with signal-to-noise ratios of greater than 20 db. A capability of 300 hours transmission at full power was demonstrated.

- **With buoys**—Unlike the proposed missile impact location system currently under consideration as Phase II of the STAR program, the Phase I system made use of submerged buoys.

Anchorage at a depth of 15,000 ft. was provided by a case containing lead-acid batteries. A sonar projector and electronics package was tethered about 100 ft. above this. In the three navigation-transducer systems, a hydrophone for reception of command signals from the attendant ship was tethered about 300 ft. above the electronics package, the whole stretch of interconnecting cable being supported by an oil-filled buoy located about 50 ft. above the hydrophone.

In the Sofar transducer system, the hydrophone was located in the Sofar layer at a depth of about 4,000 ft.—some 11,000 ft. above the battery pack. The extra amount of cable called for support by a very large air-filled buoy located at a depth of about 1,000 ft.

In the proposed Phase II STAR system, the receiving hydrophone, electronics package, and sonar projector would be mounted on the battery pack.

The electronic package associated with each transponder in the Phase I net was capable of responding to four Sonar commands: on, off, navigate, and recover. Reception of a navigate command from the ship resulted in the retransmission of a 50-msec pulse that enabled the ship to determine its position. The recover command caused an explosive bolt to sever the anchor cable, permitting the electronics package to return to the ocean surface.

Commands were transmitted as a simultaneous three-tone code of one-second duration.

Transponder circuits were made to operate at hydrostatic balance by means of compensating bladders, the circuits being immersed in an inert silicone oil.

- **Design details**—The command receiver and associated logic were designed with the aim of precluding the possibility of false alarm. Design analysis showed that the time before a false alarm response might be expected well exceeded one year. The command receiver incorporated a three-stage power amplifier. Aim of the design was low idling current, high output, and reliability.

The case of each cell in the transducer battery pack was designed to be sufficiently flexible at the sea-floor temperature of 4°C to compensate for compression of battery electrolyte. Individual cells were located in a tank filled with a transformer-grade oil and compensating bladders, to give hydrostatic balance.

Each transponder had its own specific carrier frequency and the attending ship carried a multichannel receiver. The receiving hydrophone was a line array of 21 segmented barium titanate rings. Beam-forming rejected noise that did not arrive at expected depression angles.

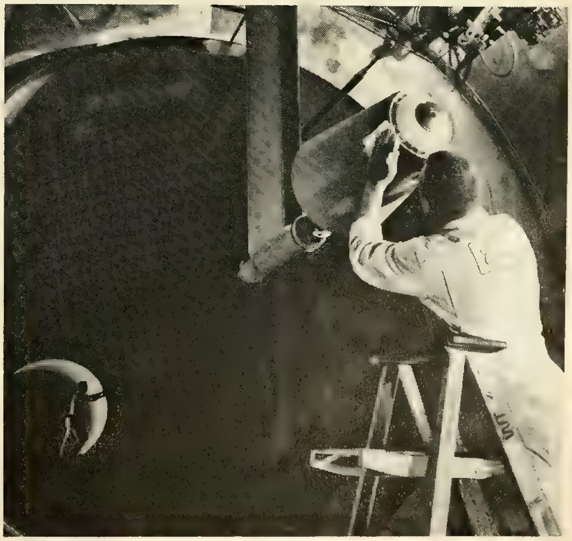
Following detection and filtering, the received FM signals were recorded. By use of different frequency bands, each of five transponder signals, a 1-kc Atlantic Missile Range time code, a 10-kc relative time code and a voice channel could be recorded on the two-track magnetic tape recorder on the ship.

During the Phase I tests, ocean currents far in excess of predictions were encountered. Use of accurately surveyed transponders on the sea bed could provide a useful tool for studying such currents, and for measuring variations in sound transmission at a specific location over a period of time.

Such transponders could also provide private navigational signposts on the ocean floor for nuclear submarines. ■

Hot Nose Cone Test

TRAILBLAZER II nose cone prepared to undergo simulated 7,000-mph flight in Cornell Aeronautical Lab's Wave Superheater Hypersonic Tunnel. Cone experienced up to 4,500° F temperature in test for MIT.



Firm Studying Method To 'Grow' Computers

RESEARCH at Space-General Corp. could lead to a technique of "growing" a computer in much the same manner the human nervous system is thought to develop.

If current research pans out, says Applied Research Laboratory director Robert M. Stewart, a technique can be developed in which a computer will be manufactured without human hands touching any of its individual components.

A computer capable of handling pattern recognition and other tasks in a manner analogous to that of the human brain might measure less than 30 cu. in., Stewart told a recent meeting of the Institute of Electrical and Electronics Engineers. It could have these advantages:

—Extremely high packing density.

—It would operate with very low heat loads, equivalent to the brain (perhaps 20 watts for 10 billion components). It would have no individual leads from each component to the monitor, and corrections would be made by applying massive shocks rather than detailed corrections.

—Capability of training the machine by showing it samples directly.

In addition, there would be no power hookups in the normal sense. The computer would be kept in a 55% solution of nitric acid, from which it would derive power. However, it might have to be kept at temperature, Space-General said.

As Stewart sees it, the manufacturing process for such a computer would be one in which the system would be put together in one day, but perhaps the rest of the year would be engaged in "training" the computer for a specific task.

Thus, once the unit left the factory, no further memory work or development of logic would be necessary. The system would be fully trained to accomplish whatever tasks the customer specified.

• **Missile/space uses**—A number of potential uses are envisioned by Space-General. Such a unit could be particularly adaptable for pattern recognition (radar, sonar, etc.), missile guidance and control, spacecraft navigation sysetms, and the operation of industrial assembly lines. It would not be particularly good at retaining large lists of numbers or items, Stewart said.

Space-General estimates that within two or three years it will have an experimental prototype of perhaps a billion components, and could manufacture in perhaps five years, with one year for delivery.

The entire finished computer would look like nothing more than a box full of wet "sand" of various sizes—pellets of iron, glass and gold or other metals —in a bath of nitric acid. Input and output wires would be used for monitoring signals and conducting stimuli.

The concept of creating this computer is based on two rather simple phenomena. It has long been known that iron wire immersed in nitric acid will react with electrical characteristics in much the same manner as animal nerve impulses. In addition, if salts of an appropriate metal are added, dendrites can be formed by electrodeposition which look much like those of animal nerve cells. These structures change in shape and distribution in response to either external or internally generated fields.

Stewart likens the development of these neuron-like structures to the learning of a child. If a child is hurt or punished when doing something, he associates the pain with whatever he was doing at that time. If the same thing happens often, he learns to avoid doing that thing. The pain could have been applied in any area—the association is with his actions immediately preceding it.

In the same manner, Stewart theorizes, if an electric shock is given as "punishment" to the computer mass of iron, glass and gold pellets, it tends to produce structural changes in a very specific manner. This is evidenced by the fact that an iron wire that has been excited has a surface resistance of less than 1% its resting value. Therefore growth is much higher in this area than elsewhere.

• **How to train**—Thus, a computer which was to make pattern-recognition decisions would be given stacks of photographs—friend and foe—in a direct manner. Each time a pattern was shown, the machine would make a response. If it were unacceptable, a shock would be applied immediately.

"Graduation day" would come when the "memory" was deemed sufficiently developed, and the computer responded with the desired signal each time it saw a foe.

The electric shock unit would be disconnected, and the computer would be shipped to the customer.

Space-General now is looking into the possibility of developing a chemical retina which would allow the machine to absorb photographic and other visual material directly. A lens would be built into the box, and the picture held up to it. The group hopes to have this experiment ready within six months to a year.

• **Drawbacks**—There are of course disadvantages to the system. The nitric acid bath tends to become polluted with nitrous acid and must be changed, although a continuous changer could be built. However, for short-term units, like missile minds, the acid bath could be temporarily purified right in the unit without changing it. In addition, if the system is to be used for long term operation, it must "sleep" for a few hours in another fluid.

Stewart makes no predictions as to the accuracy of his unit in making judgments if the "foe" does not look exactly like the photograph. This will have to be resolved in detailed tests, he indicated.

The concept upon which the system is based—that dendrites in the brain may be the seat of memory, is by no means proven. In fact, there is a great deal of doubt in some quarters that electrical interactions are really the basic functional connection between nerve cells. Thus, this research could shed a great deal of light on the physiological processes of learning mechanisms and memory.

Stewart's group also is looking at a number of other materials which could be used in the construction of the "computer." Requisite is that they hold up in hot nitric acid, and be good conductors.

The work has been partially supported by the Bionics and Computer Branch at Wright-Patterson AFB. ■

Crystal Formation from Vapor Probed

A SERIES of studies into the form, structure and growth of silicon whiskers at Bell Telephone Laboratories, Inc., is the basis for a new concept of crystal growth from vapor.

Bell researchers R. S. Wagner and W. C. Ellis described their process in the March 1 issue of *Applied Physics Letters*. Designated the Vapor-Liquid-Solid (VLS) Mechanism, the concept can be applied to most crystalline substances to grow diverse forms—varying from whiskers to epitaxial layers. The crystals are near-perfect in structure and can be grown at temperatures lower than those involved in current vapor-phase crystal growth processes.

- **Alloy production**—In the VLS mechanism, an impurity is used to form a liquid alloy droplet of relatively low freezing temperature. The droplet is a preferred site for deposition from the vapor, say the Bell experts, which causes the liquid to become supersaturated with the base material—in this case silicon.

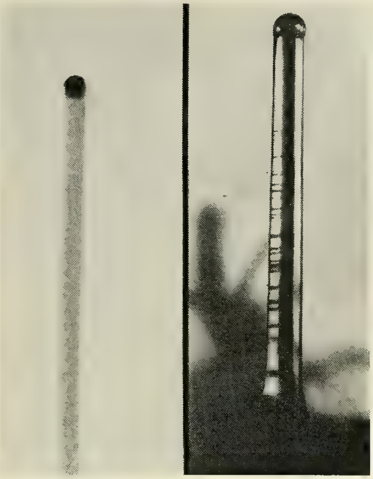
The whisker in the experiment grows by precipitation of silicon from the droplet. Because the whisker grows from the liquid, a screw dislocation is unnecessary. Wagner and Ellis drew three facts from the studies and subsequent work in which silicon whiskers were grown by the disproportionation of SiI_2 or by the hydrogen reduction of $SiCl_4$.

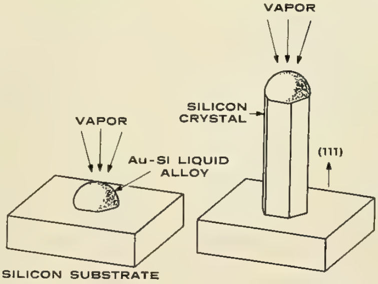
The first is that silicon whiskers do not contain an axial screw dislocation. The second is that an impurity is essential for whisker growth.

The third postulate is that a small globule is present at the tip of the whisker during growth.

From the first fact and related evidence, the Bell researchers say it is clear that growth from the vapor did not occur by the Frank screw dislocation mechanism.

The VLS mechanism emerged from the last two statements and much additional evidence. In their description of the VLS mechanism, Wagner and Ellis cited the growth of seeded whiskers of silicon using gold as an impurity.


1,000-ANGSTROM whisker (left) and 0.2 mm needle (right) show wide cross-sectional dimensions available with the Vapor-Liquid-Solid method. Crystal growth was interrupted for these photographs.



GROWTH TEST used gold as impurity, but similar results were obtained with platinum, silver, palladium, copper and nickel by substrate placement or co-deposition.

A small particle of gold is placed on a [111] surface of a silicon wafer and heated to 950° C, forming a small droplet of Au-Si alloy. A mixture of hydrogen and $SiCl_4$ is introduced. The liquid alloy acts as a preferred sink for arriving silicon atoms, say the Bell workers, or, more likely, as a catalyst for the chemical process involved.

- **Riding effect** —The silicon enters the liquid and freezes out, with a very small concentration of gold in solid solution, at the interface between solid silicon and the liquid alloy.

Continuation of this process displaces the droplet from the substrate crystal and rides atop the growing whisker. The growth direction <111> (diagonal) and the side faces of the whisker are usually [211] but sometimes [211] and [110].

The whisker grows in length by this mechanism until the gold is consumed or until growth conditions are changed.

VLS growth of silicon whiskers can occur over a wide range of cross-sectional dimensions, say Wagner and Ellis.

The selection of a proper impurity for VLS growth depends on a number of factors such as the formation of a liquid alloy at the deposition temperature, vapor-liquid-solid interfacial energies, distribution coefficient and inertness to the reaction products.

The Bell researchers use the term "impurity" in a broad sense. For example, in the VLS growth of compound crystals, such as GaAs, an excess of one of the component materials can act as a liquid-forming impurity. In some cases, a combination of two or more impurities can be used.

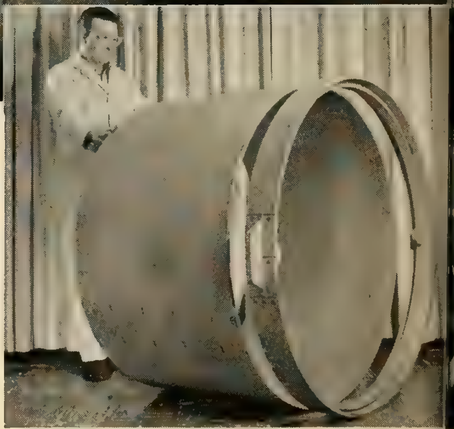
Wagner and Ellis credit the VLS mechanism with explaining many observations on the effect of impurities in crystal growth from vapor. Crystals of α-Al_2O_3 and SiC—which have been shown to have rounded terminations—may have grown by the VLS mechanism.

The proposed mechanism has widespead applications to the growth of both filamentary and macroscopic crystals and of epitaxial layers. Controlled growth can be obtained, say the Bell experts, through the appropriate use of impurities in patterns or films on substrate surfaces and on single crystal seeds of many substances. P-N junctions and heterojunctions can be made and dislocation-free crystals can be grown.

Bell Telephone's William G. Pfann, a contributor to the development, says the technique has great technological potential for semiconductor, laser, piezoelectric and magnetic devices. ■

Titanium

Size is no object. Small titanium bottles, made by D-K Manufacturing Company, Chicago, from Wyman-Gordon Co. forgings, hold 150 cu. in. of oxygen at 3,000 psi and weigh only 3.65 pounds. On the other end of an almost unlimited scale of size is the titanium tank made from sheet metal by Beech Aircraft. It measures 8 x 24 ft., holds 7,000 gallons of liquid hydrogen, yet weighs only 473 pounds.



TITAN III oxidizer and fuel tanks. Ti-6Al-4V is used for upper-stage nitrogen tetroxide tank (46 x 174 in.) and the unsymmetrical dimethylhydrazine tank (63 x 154 in.). Shown above is one of the titanium roll forged cylinder sections and stiffener rings produced by Ladish Co. for Martin Company for use in tank construction. Final machining and welding are done *after* heat treatment, eliminating distortions and production difficulties inherent in many heat-treatable metals.

or tankage . . . big or little, hot or cold

Compatible with space-age fuels . . .
readily available in a range of alloys . . .
fabricated from sheet or forgings . . .

In short, there are good, metallurgical reasons why titanium tanks and vessels—more than 5,000 of them—are aboard just about everything that flies today. They come in all sizes, handle all types of fuels and gases, save vital pounds, add stiffness and strength to structures. Here are a few of the reasons why:

High strength-to-weight. Titanium weighs 44% less than steel yet is stronger. It has a high yield strength, good ductility, notch toughness all the way down to *minus* 423F. It offers high buckling resistance at less weight than other metals.

Compatible with fuels and gases. Titanium shows outstanding resistance to liquid and solid fuels and oxidizers in use today or planned for the future. Its impermeability to hydrogen and resistance to sea-water and atmospheric corrosion mean thorough reliability and indefinite storage life.

Alloy availability. A variety of titanium alloys are available for tankage construction — two of them in Titanium Metals Corporation of America's ELI (extra low interstitials) compositions, developed specifically for liquid hydrogen service. Only TMCA can supply all titanium alloy grades in any commercial product or size required.

Meets fabricability requirements. Titanium is at home in the two important approaches to tank construction: the use of machined roll forgings and the application of thin-gage sheet. Titanium is fabricated on conventional equipment. Add these facts together, and you'll find that titanium is your single, most efficient material of construction for tankage, regardless of size.

For more information . . . write for new Data Sheet on titanium tankage. Write Technical Service Department, Titanium Metals Corporation of America.

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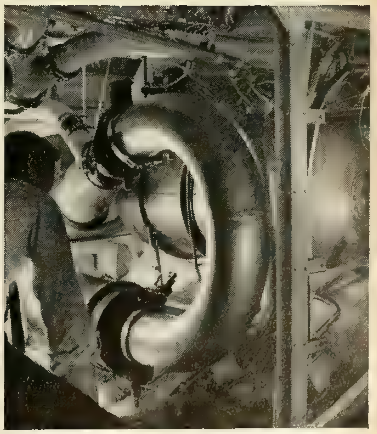


MINI Titanium pressure vessels. Vessels used throughout mini spacecraft are made from titanium to minimize deadight which must be lifted off the ground. Shown here are titam hemispheres hydroformed by California Hydroforming mpany, Inc., El Monte, California. **APOLLO liquid hydrogen ttles.** Pressure vessels are produced from titanium alloy grade 5Al-2.5Sn ELI to provide exceptional toughness to cryogenic nperatures. A typical bottle weighs only 12.9 pounds, has a ll thickness of 0.031 in.; at the weld girth, 0.044 in.

MINUTEMAN titanium second stage. Cylindrical sections possess great stiffness at minimum weight. Minuteman cases consist of roll forged cylindrical sections welded together. Titanium welds are as strong or stronger than parent metal, are less sensitive than steel to weld porosity and need no pre- or post-heating. **Titanium water bottle costs less than fiberglass,** weighs 17 pounds less than steel or fiberglass and is used on Boeing 727 as the most efficient way to save weight. Shown also in photo is titanium tubing for cabin heat system.

Circle No. 8 on Subscriber Service Card

NASA Tells Congress Early Plans For Semi-Permanent Base on Moon

Gray outlines projected unmanned landing of LESA, which would be joined by LEM; agency also releases Boeing study

by William Beller

THE FIRST OUTLINE of what may turn out to be a multibillion-dollar program for establishing a semi-permanent U.S. base on the Moon was broadly sketched by a NASA official during current hearings before the House Space Committee.

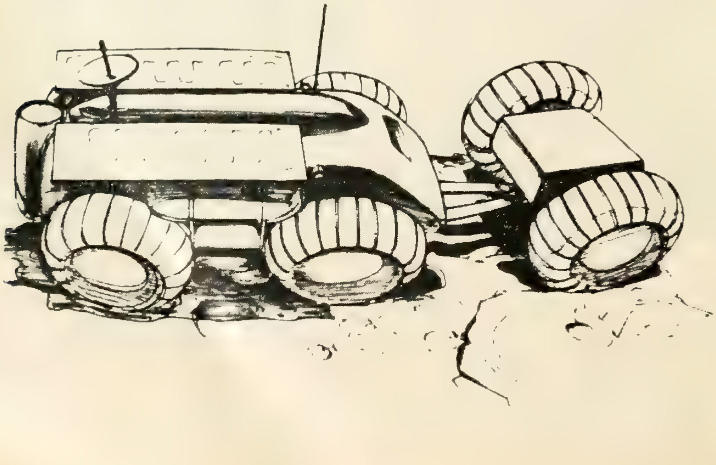
The space agency at the same time released an extensive NASA-sponsored study looking into the question of establishing a base on the Moon after the *Apollo* manned lunar-landing mission is accomplished.

The study, made by the Boeing Co., draws up the general concept of a complete lunar-base system consisting of prefabricated modules launched by *Saturn V* rockets.

The present *Apollo* launch vehicles will be able to carry about 7,000 lbs. of payload to the Moon, with a resulting payload volume of about 2,000 cu. ft. "This would provide a shelter with occupancy capability for two men for about 14 days on the lunar surface," E.Z. Gray, NASA's director of advanced manned missions, told the Congressional committee.

He suggested that the least expensive system that could be devised for supporting two men on the Moon, plus giving them the tools for exploring the lunar surface, would include a "two-man roving vehicle." This would be landed as an alternate payload by a Lunar Excursion Module (LEM) truck. It would be designed to cover about 200 to 300 miles on the lunar surface in the 14-day stay-time of the astronauts.

BOEING STUDY includes drawing of this semiflexible lunar surface vehicle.



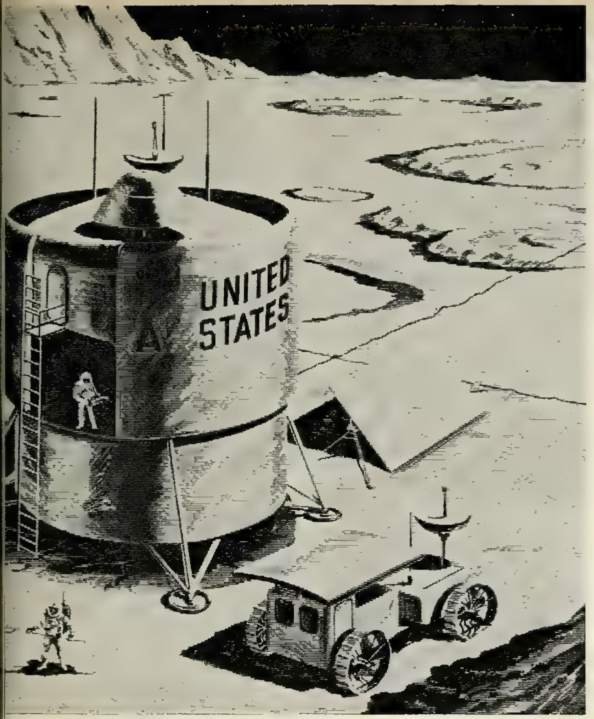
- **Settling in**—Looking beyond the two-week, economy-plan stay on the Moon, Gray described a Lunar Exploration System for *Apollo* (LESA), weighing about 25,000 lbs. per module (M/R, Feb. 10, p. 18). Launched by a *Saturn V* without an *Apollo* spacecraft, LESA would be delivered unmanned directly to the lunar surface. It would be followed by a manned *Apollo* launch. Possibly using a homing radar, the LEM vehicle would land near LESA.

The basic LESA module, with a volume of about 3,000 cu. ft., would be able to provide satisfactory shelter and life support for three men to stay 90 days on the lunar surface.

The Boeing study, on which the LESA concept is based, assumes that crews each made up of three men are delivered to the lunar base. Each crew will spend no more than six months on the lunar surface.

Several models of lunar bases are now suggested by Boeing: in the first, a crew of three men would spend three months on the lunar surface. Their mission would require a surface vehicle able to cover 1,500 miles. Each crewman would use his spacesuit 120 hours.

A second model calls for a crew of six to spend six months on the Moon. Vehicle mileage would be 3,000 miles, spacesuit usage, 320 hours. Similarly, a crew of 12 is suggested for stays over one year. The vehicle would be required to go 4,500 miles, spacesuits, 750 hours. For a stay of more than two years, Boeing recommends a crew size of 18, a



LUNAR-BASE module for three men dwelling three months.

vehicle able to traverse 7,500 miles, and spacesuits able to hold up for 1,250 hours.

Typical lunar missions for the astronauts would be lunar surface reconnaissance; geological and geophysical reconnaissance and survey; geophysical research on mare formation, crater shape and thermal anomalies; and economic geology.

The report studied laboratory missions in less detail, but did emphasize possible scientific and technological equipment requirements for astrophysical research and chemical synthesis pilot-plant operation.

- **Expansion**—A lunar base may be established by direct buildup to a specified capability, according to the Boeing study, or may grow in size over a period of years. The evolutionary approach is recommended because it is "most compatible with the *Saturn V* launch capability expected in the 1970 time period."

Surprisingly, Boeing finds that lunar exploration may proceed on a gradually expanding evolutionary scale, from a small initial to an eventual major base installation, "without penalty on a gross cost-effectiveness basis."

The lunar base may be expanded simply by adding more of the basic shelter modules and suitably equipping them. The proposed Boeing module has an interior volume of 2,813 cu. ft., said to be a generous allowance for a six-man crew. Each of the men is allowed 469 cu. ft. inside the protective shelter, which is a space of approximately 7.5 x 9 x 7 ft. high. Stores and equipment take up about half of this volume.

The shelter is described as a rigid structure consisting of two concentric pressure vessels, providing redundancy for pressure integrity and additional radiation protection for the living space. Aluminum would be used for the structure and meteoroid shielding.

However, Boeing held out the possibility of "significant weight savings" by using maglithium, Lockalloy or beryllium alloys in place of the aluminum. Nevertheless, said the study, "considerable effort is required to extend the art in working with these materials to a point at which their utilization is possible."

- **Atmosphere**—Instead of using a pure-oxygen atmosphere in the lunar base, Boeing is recommending an oxygen-nitrogen atmosphere at 6.0 psia for normal operations. Physiological considerations, particularly decompression sickness, figured in this decision.

All bases will require an initial supply of oxygen, part of which could be used for emergency purposes if oxygen recovery is made part of the life support system. Oxygen could be recovered from the astronauts' metabolic CO_2, but this alone would be insufficient to serve the needs of a base.

Boeing suggests that fuel-cell byproduct water is very promising as an oxygen source and, together with oxygen recovered from the metabolic process, can eliminate or greatly reduce the need for oxygen resupply. Fecal water recovery is said to be necessary only on the large bases.

- **Energy**—The study confirmed other findings that nuclear power is the best energy source for all but the smallest lunar bases. In particular, "The SNAP-8 100-kilowatt, two-alternator system appears to be a very practical, reliable power module for application to large central nuclear powerplants on advanced bases."

Boeing points out, however, that other power systems should be looked into for the 90-day base application. "The fuel-cell/solar-cell system appears to be the most practical concept; however, intensive studies should be made to evaluate and compare radioisotope concepts in the 1.5- to 3.0-kilowatt range."

- **Communications**—Lunar communications are not expected to cause any problems except for point-to-point communications beyond the line of sight on the lunar surface. Because the lunar horizon is so much closer to an observer due to the relatively small lunar radius, and because the Moon has no appreciable ionosphere, LF (approximately 50 kc) surface-to-surface communications may be feasible for transmitting voice or telegraphy beyond the line of sight. This concept may also provide "an aid to exploration and a means of navigation on the lunar surface with modest transmitter power and a simply erected horizontal dipole antenna."

- **Land vehicles**—For a lunar-surface exploration vehicle, Boeing states, "the rolling mode (is) the most feasible means for accomplishing a variety of mobility tasks." A detailed analysis was said to show that large wheel diameters with large deflections and multi-axle vehicles with flexible chassis have superior mobility.

The Boeing study also brought out a theory of maintenance far different from the one usually employed on Earth-bound systems. For a lunar base, emphasis is placed almost entirely on equipment reliability rather than on any maintainability, including preventive maintenance. If a unit fails, then the stress will be on replacing it at the module or major component level.

- **Biggest problems**—There are two major problem areas, says Boeing. The first is knowing the meteoroid hazard. At this time, the meteoroid environment on the lunar surface, including the contribution of secondary particles, is completely unknown. Thus, the problem of determining the shielding needed for meteoroid protection is indeterminate.

The second problem is that of "defining spacesuit performance." Clearly, the entire concept of lunar exploration depends on how well the astronauts can function in their suits. The Boeing study assumes the spacesuit goals of the *Apollo* project are met, an achievement admittedly based on technical advances not yet in hand.

The Boeing study observes that tooling-up for lunar base modules should begin about four years before U.S. astronauts land on the Moon. This means that by 1966 all preliminary studies should be completed and the R&D phase begun if the Kennedy schedule for a lunar landing is to be met. ■

New Apollo Guidance System Could Become Standard for Future

Block II G&N system will add computer redundancy while cutting weight; MIT developing design; a report on Block I work at AC Spark

by Charles D. LaFond

MILWAUKEE—The recent decision to embark on design and development of a Block II *Apollo* guidance and navigation system for use in both the Command and Lunar Excursion Modules may be far-reaching. This new, lightweight, advanced G&N system could evolve as NASA's "Standardized Space Guidance System" for future manned spacecraft.

As presently conceived, Block II hardware will significantly increase computer redundancy and still provide a total *Apollo* G&N weight decrease of 250 lbs.

The decision, not yet announced by NASA, was made by the Manned Spacecraft Center at Houston roughly four weeks ago. It resulted from the need to reduce payload weight and to standardize *Apollo* subsystems as much as possible. The new guidance system, now under development at MIT, will be similar in basic design to the Block I system now approaching the testing phase.

It will, however, more closely represent the current state of the art for such a complex inertial guidance system in size, weight and redundancy.

The original Block I system included a Command Module (CM) guidance package weighing about 500 lbs. and a Lunar Excursion Module (LEM) guidance system weighing about 350 lbs. Subsystems employed in LEM will be essentially the same as those in the CM but require fewer black boxes.

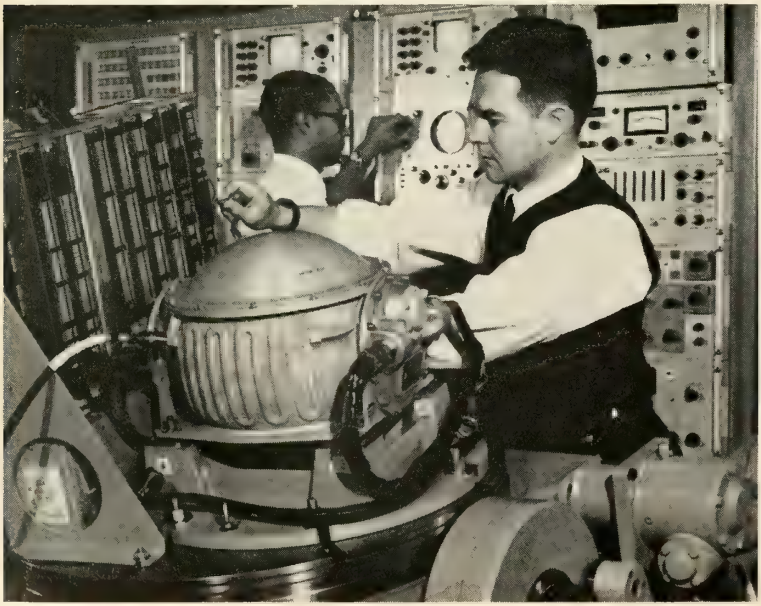
In the Block II system, G&N for the Command Module will weigh 400 lbs., for the LEM system only 208 lbs.

First complete Block II system should be ready by late 1965, say NASA officials, and may even be employed operationally in some early *Apollo* flights.

- **Block I status**—The present G&N system is being developed under the direction of the Instrumentation Laboratory of MIT, *Apollo* associate prime contractor. (For hardware details, see M/R, Oct. 7, p. 54.)

AC Spark Plug Div. of General Motors is responsible for overall system assembly and integration and a major part of the system engineering and environmental testing. Also, AC Spark builds the Inertial Measurement Unit (IMU), Navigation Base (a common mount for the stable platform and optics), Coupling Data Units, the Power and Servo Assembly, and associated panel controls and test and checkout equipment.

Raytheon Co. is developing the digi-



LEFT: Laboratory engineers at General Motors AC Spark Plug Div., Milwaukee, check first Apollo Interial Measurement Unit, Power and Servo Assembly, associated electronics and ground support equipment. This is first unit to be manufactured on production tooling. RIGHT: An AC Spark Metrology Laboratory technician checks parallelism between Inertial Measurement Unit and optical system mounting pads of Apollo Navigation Base. Latter is one of largest single pieces of beryllium ever machined in U.S. FAR RIGHT: This guidance and navigation panel is part of display and controls for Apollo Command Module. Lower left panel contains readouts for the five Coupling Data Units.

tal flight computer, which employs a 24,000-word (15 bits per word) fixed-data memory and a 1,000-word scratch-pad memory. The firm also is building the associated keyboard, display and support equipment.

Kollsman Instrument Corp. is building the G&N optical subsystems: a movable telescope, sextant, and a photometer attachment for horizon sensing.

As the program now stands, AC Spark Plug has two complete IMU's in test, the computer development is behind schedule (none delivered yet to AC Spark), and the first optical subsystems were delivered earlier this month to AC Spark's Milwaukee facility. A government-furnished two-axis test fixture for the optics was installed, stabilized and calibrated there in February, and the optics are now undergoing test and calibration.

Initially, five complete systems will be built. First, two will be tested by AC Spark, and one will be retained as an engineering model. The first complete G&N system is still expected to be delivered to North American Aviation, Inc., *Apollo* prime contractor, in April. A second will be sent to Houston in May. The remaining three systems will be readied thereafter—one every two weeks. (Eleven more will then be built under the present contract.)

After spacecraft integration this summer, NAA will perform acoustical and vibration testing, while NASA's MSC will conduct thermal and vacuum tests.

A fourth system will be delivered to MIT for engineering evaluation and the fifth will be retained by AC Spark for complete subsystem environmental testing.

- **Block II modifications**—All electronics in the Block II G&N flight hardware will be repackaged to minimize size and weight.

The present IMU weighs 60 lbs. The new stable platform will be 20 lbs. lighter.

The present five CDU's (Coupling Data Units) are essentially data converters interconnecting the IMU, computer and optics. Currently employing mechanical readout (three gimbal angles and two optical angles), the redesigned CDU's will be all-electronic.

Wherever practicable, microelectronic circuits will be employed in the new computer, CDU's and Power and Servo Assembly.

In the Block I concept, one 80-lb. computer will be used in the Command Module (originally, it was planned to make use of spare modules and in-flight maintenance and repair, but this is no longer true). A second computer, with different programming, will be used in LEM. For Block II, two 42-lb. computers will be used in the CM—one operating and one in active standby. The latter will be energized and updated periodically by one of the pilots.

The present optics are all manually operated. In the new system, an auto-startracker is being considered and is being developed.

- **LEM contractors**—The same G&N contractors for the CM now have small LEM G&N study contracts from NASA. For the sake of continuity (and practicality), these contractors eventually are expected to win awards for Block II (and LEM) G&N development.

The LEM backup (abort) G&N will take the form of a simplified strap-down inertial guidance system. Such a subsystem probably will be a part of the flight stabilization and control (S&C) system—as is the case with the Honeywell S&C system in the Command Module.

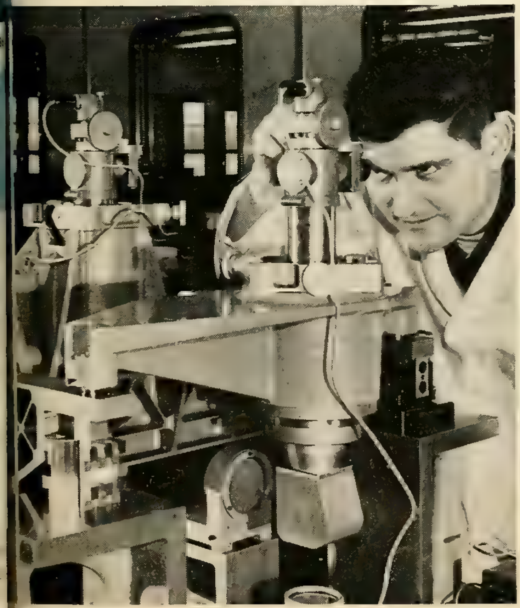
(In February, Grumman Aircraft Engineering Corp., LEM prime contractor, through a letter of inquiry had asked for comment from a number of G&N system manufacturers concerning the backup system. Results of this "survey" have not yet been released, but the decision to employ strap-down IG has been made and an RFP will go out to industry from Grumman soon.)

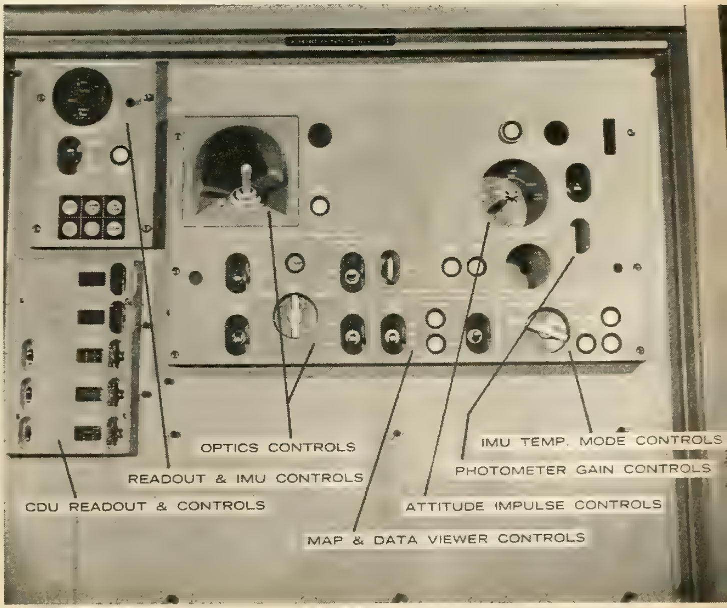
- **Configuration control**—To assure G&N design control and reliability in both Block I and II, rigid configuration control has been maintained by MIT and NASA. The result so far is a mountain of paper work, but proponents claim the payoff will come in the form of rapid solutions to field failures.

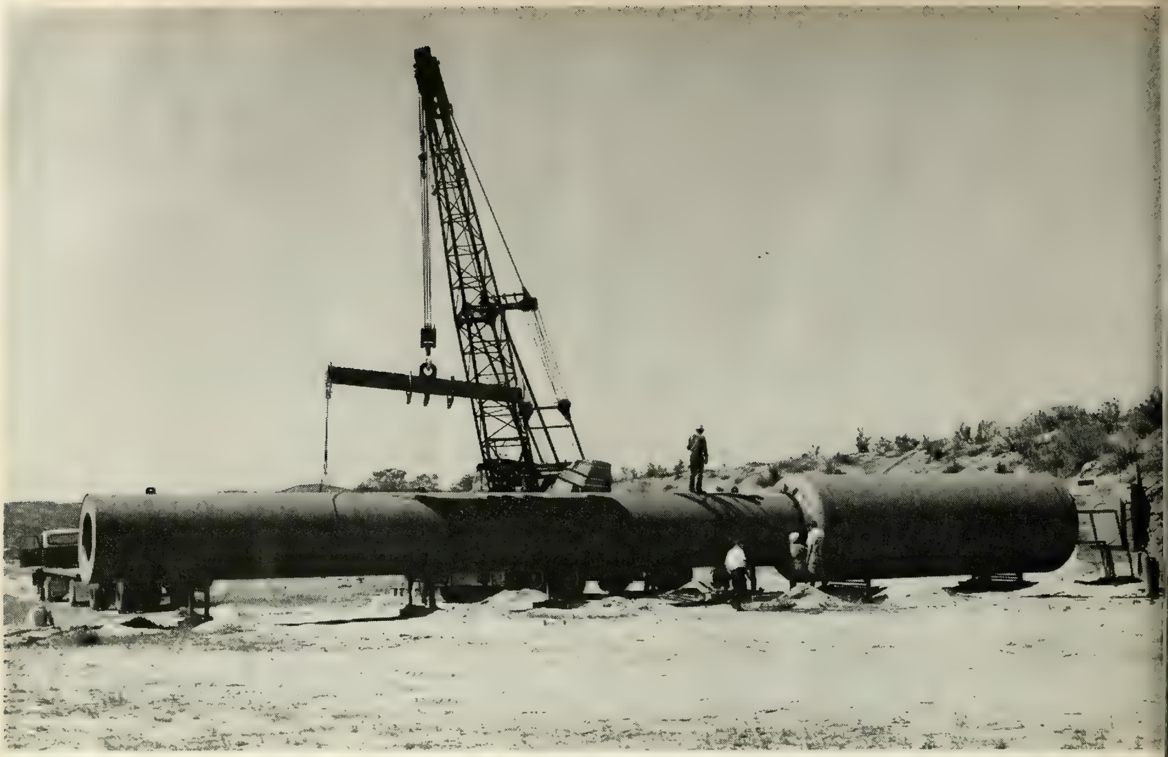
Maintenance of this control is accomplished through two working groups: the Change Control Board (CCB) and the Design Review Board (DRB). CCB is made up of MIT and NASA personnel; DRB is similarly made up, but includes personnel from the G&N contractors team.

The latter contributes the first review of any requested design change. This is an engineering review and is concerned chiefly with the overall design requirements and reliability. The CCB reviews changes for effectivity, cost and need.

A key element in the control mechanism is complete identification of all parts used in the G&N system. The CCB must be informed of any parts or process change from contractors or vendors. ■







IGNITER MOTOR for 156-in. solid is tested in this 90-ft. bore simulator.

space propulsion

First 156-in. Solid Motor Readied By Lockheed for Late Spring Firing

Air Force-funded feasibility demonstration program could lay groundwork for super ICBM's; second test shot set for fall

by Willard E. Wilks

REDLANDS, CALIF.—The first 156-in. solid rocket motor is being prepared for a late spring firing by Lockheed Propulsion Co. here. A second firing under a $6-million Air Force feasibility demonstration contract is scheduled for early fall.

Although work has been under a Space Systems Division contract, others, including Ballistic Systems Division, Air Force Systems Command, and the Office of the Director of Defense Research and Engineering have expressed considerable interest in the program and in the 156-in. application study in which LPC has participated with Lockheed Aircraft Corp.'s Missiles & Space Co.

Air Force has considered new super ICBM's using a 156-in. booster that would fit in certain existing silos, and National Aeronautics and Space Administration has conducted some investigation into the possibility of using 156-in. strap-ons for *Saturn V*. The possibility of a flight of a single-segment motor using *Polaris* autopilots and guidance existing at Vandenberg Air Force Base also has been investigated.

Ballistic Systems Division representatives recently were briefed at LPC for background on 156-in. transportatio problems.

- **Thrust figures**—Thrust level i the first firing of the single-segmen motor will be slightly under one millio pounds, approaching that of the five segment, 120-in. motor in order to tes a nozzle similar to a type that could b used on *Titan III-C* with some modifica tion and development.

The nozzle, with an ablative throa and jet tab thrust vector control, is gov ernment furnished equipment provide by Thompson Ramo Wooldridge.

For the first firing, the propellan load will be reduced, resulting in a co respondingly larger cylindrical port size. Propellant is the same type as that used in the 120-in. motors produced by United Technology Center. Loading was completed last week.

In the second firing, using the same case, about two-thirds of a million pounds of propellant will be used to produce a 20% higher thrust level of more than a million pounds.

This represents the difference between the *Titan III-C* five-segment 120-in. motor and the single-segment 156-in. rocket. Nozzle will be virtually the same type but designed for the larger thrust level. Burn times will be about two minutes.

The second firing will be a complete flight weight design except for the TVC power supply.

Neither firing will demonstrate the full capability of the 156-in. motor. The contracts now in being at LPC and at Thiokol Chemical Corp. call for a motor designed around a specification that suits the low-q and low-g limitations imposed by typical NASA missions, in which the 156-in. would boost iquid upper stages. This resulted from he Department of Defense-NASA agreement in 1962. Coincidentally, the q and g limitations also are peculiar to *Titan III-C*.

- **Flexible program**—Utilizing the same hardware but adjusting the burnng rate, thrust levels of two to three imes more could be demonstrated, LPC President Robert Hurt says. "The program is flexible. It permits, with essenially the same hardware, development of the types of boosters that can be used for NASA space missions, Air Force space missions or missile applications. We might be able to acomplish 10 missions with only slight booster differences, and with terrific ost savings as a result."

The LPC motor is nearly all state-f-the-art technology. New items inlude jet tabs in a large engine and use f 18% nickel maraging steel plate for he case.

The spring demonstration will be a ontinuance of full-scale tests on the et tabs, and only two pairs operating n two quadrants at the aft end of the ozzle will be used. These, however, vill include four tabs of slightly diferent design and material. Refractory materials evaluated for the tabs have een narrowed to five. The first firing ill trim this still more.

In the fall firing, LPC expects to arrow the choice down to one tab degn, and the full jet tab system using our pairs will be demonstrated in a 56-in. motor for the first time.

The tabs are hydraulically actuated, hich LPC believes may be the most economical approach. The actuators are f-the-shelf hardware provided by

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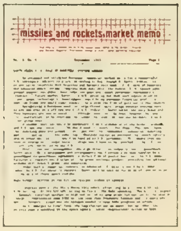
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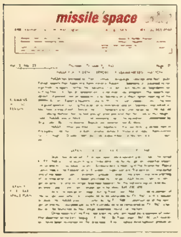
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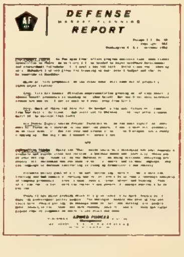
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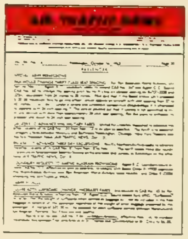

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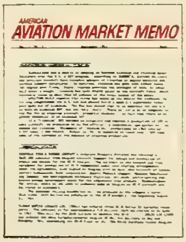

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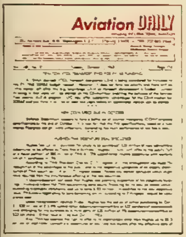

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Use of a pair of tabs per quadrant increases efficiency because of a low insertion depth/width ratio. The multiple tab system also makes it possible to use the tabs for roll control. Reliability is increased since in case of complete failure of one tab, adjacent tabs can contribute enough to maintain a total control force of 70-80%.

- **Maraging steel used**—The forthcoming tests will be the first of a large motor case made of maraging steel. Needing no large heat treat in case fabrication, the metal can be welded and treated locally. Subcontractor to LPC for the case is Excelco Developments Inc., Silver Creek, N.Y., working with U.S. Steel, Standard Steel Works, Burnham, Pa., and Pittsburgh DesMoines Steel Co.

The single-segment motor consists of three sections. Center portion, which holds more than a third of the propellant, is made of two welded cylindrical pieces and is 265 in. long; forward section is 242 in., and aft piece is 220 in. long. Segment joints are tapered pin, clamp bar and O-ring. Overall motor length, including nozzle, is 75 ft. The entire motor will weigh 250 tons loaded in the first firing, 350 tons in the second.

The igniter motor itself is large—22.2 in. dia. and 58.5 in. long. Its burn time is only a little more than one second. Four ports in the aft end spread the flame out over the propellant. The igniter is half again as large as the *Mercury* escape motor.

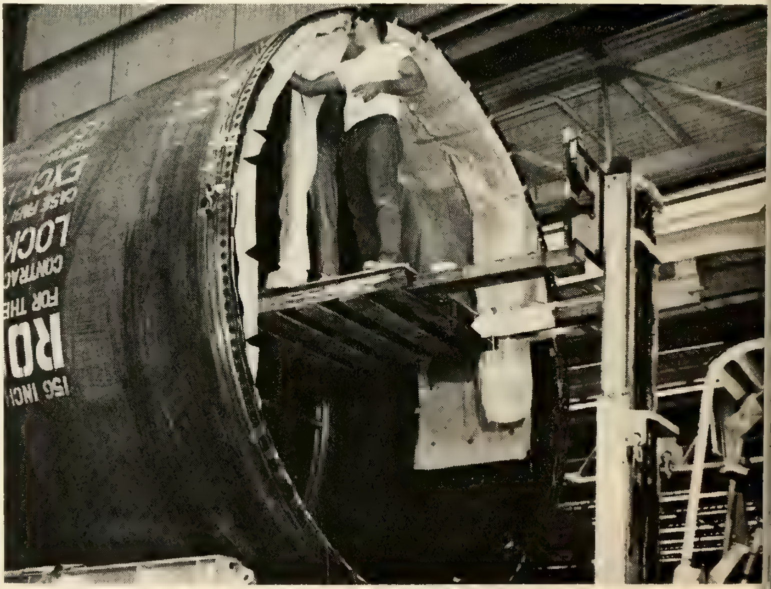
LPC designed and developed the igniter and igniter simulator. The simulator, in two sections totaling about 90 ft. overall, simulates the two port sizes in the scheduled firings. Volume of the two sections together, about 5 ft. and 7 ft. in diameter, simulates the port size of the first motor; that of the smaller diameter section simulates that of the second motor.

- **Few program restrictions**—John W. Buffington, assistant program manager, points out an advantage of the project is that it was not tied to any specific hardware program. "We can demonstrate the feasibility of the large solid at the same time and parallel to the large amount of effort going into application studies.

"When studies have been completed and we know from a theoretical standpoint what we would like to have in the way of larger motors, we will already have demonstrated feasibility. There won't be anyone saying something is too optimistic because we will have tested and shown what can be done. This will have been placed on the practical level and there should be no worry about downgrading missions."

Other LPC suppliers on the program include Northwest Industries, Climax Molybdenum Co. of Michigan, Universal-Cyclops Steel Corp., Bridgeville, Pa., Wah Chang Corp., Albany, Ore., Thermo-Electron Engineering Corp., Waltham, Mass.—jet tab refractory material; BMW Manufacturing Co., Torrance, Calif.,—mandrel; Rohr Corp., Riverside, Calif.,—insulation of segments, and LMSC, technical support in jet tab studies. ■

ROHR CORP. specialist lays in pressure bags over buna rubber insulation in center 156-in. segment. Rubber is then bonded to case.



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In response to numerous requests asking if the Motorola Integrated Circuits Course held last summer will be offered again, we are pleased to announce that a one-week course will be given during the week of May 11 - May 15 in Phoenix, Arizona

The new Motorola Integrated Circuit Design course combines the results of years of research, theory, and practice into a week of concentrated study that will enhance your integrated circuit design capability. It is recommended for engineering management personnel who are or will be responsible for directing their company's development of either linear or digital equipment using integrated circuits.

Leading authorities will provide instruction covering a broad scope of integrated circuits, ranging from integrated circuit technology to circuit analysis. Emphasis will be on monolithic circuits although the role of thin films and multiple chip circuits will be included.

The Motorola Integrated Circuits Design Course includes • Basic device theory • Semiconductor processing and wafer assembly, epitaxial growth, diffusion, packaging • Passive elements for integrated circuits • Active elements for integrated circuits • Fundamentals of monolithic design • Thin-film technology • Characterization of logic circuits • Current mode logic analysis • Considerations of low-power logic circuits • DCTL circuit analysis • DTL circuit analysis • T²L circuit analysis • Comparison of various logic circuits • Fundamentals of integrated amplifier design • Design of high-frequency tuned amplifiers • Band-pass amplifier design.

Fee for the one week course is $450.00 and includes tuition, course materials, and weekday luncheons. For complete details fill out and mail the attached coupon!

MOTOROLA

Semiconductor Products Inc.

DEPT. TIC 97MR3 • BOX 955 • PHOENIX, ARIZONA 85001
A SUBSIDIARY OF MOTOROLA INC. 97MR3

On Friday, July 12, 1963, more than 160 top level engineers representing major industrial and military electronic equipment manufacturers in the United States and Europe left their respective laboratories and offices to converge on Phoenix, Arizona. This object: to take part in an integrated circuits program designed to telescope the educational lag in this new technology.

The course, sponsored by Motorola Semiconductor Products Division, marked the first known instance of a company in the highly competitive semiconductor industry extending a blanket invitation to learn how integrated circuits are produced and how to design for this technology.

Comments by those who attended speak favorably of this program . . . comments such as "a unique textbook that will be talked about for months to come . . . ", " . . . probably could not have been done by any other company in the field", " . . . by far the best compilation of information concerning the technology".

Now, at the request of companies who were unable to attend the first session, Motorola will present a second phase – a condensation and updating of the original course.

MOTOROLA INTEGRATED CIRCUIT DESIGN COURSE

Box 955 • Phoenix, Arizona 85001

Please register the following for the Motorola Integrated Circuits Design Course:

NAME____________________

TITLE____________________

COMPANY__________ PHONE__________

STREET____________________

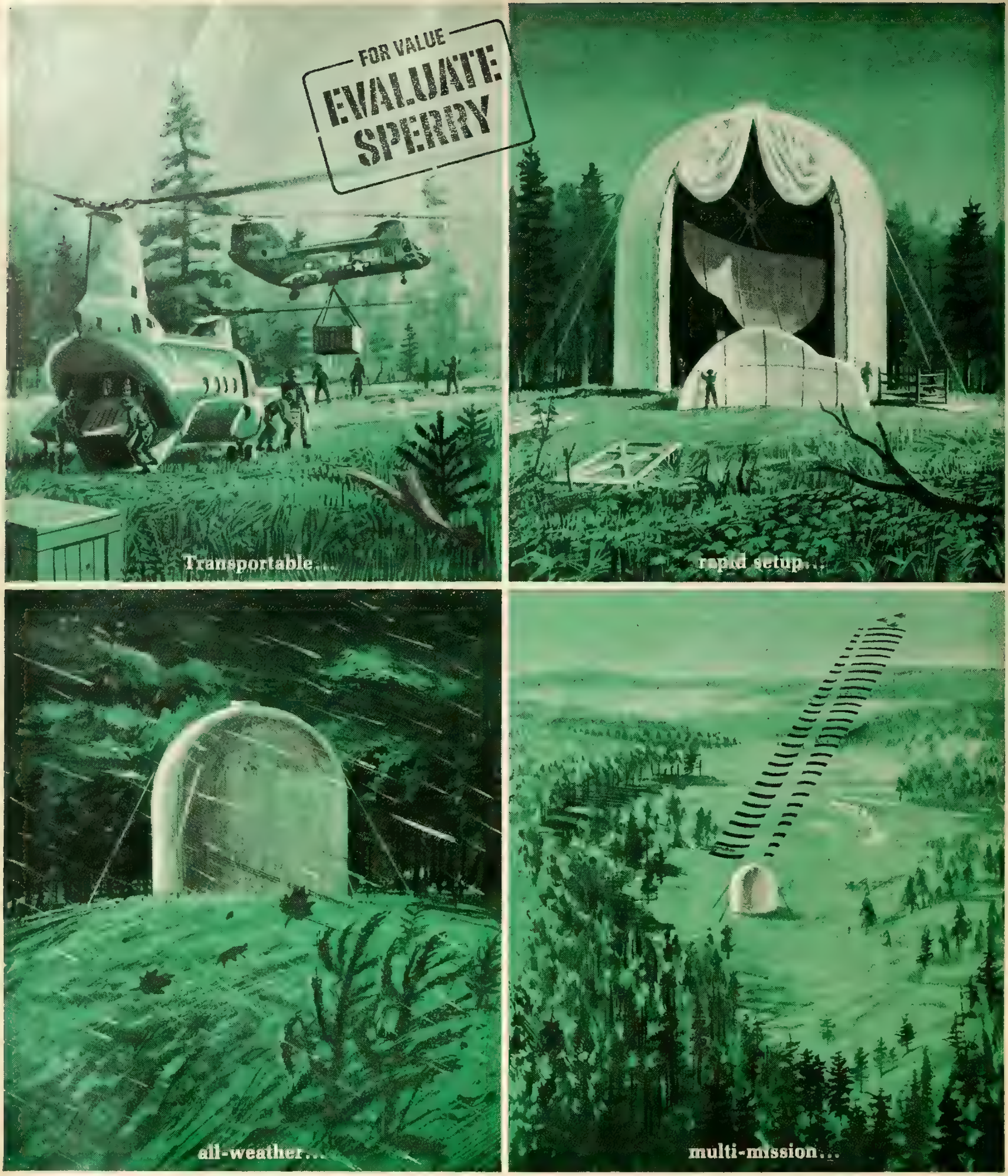
CITY__________ STATE__________

☐ Check enclosed ($450.00 per person . . . Make check payable to Motorola Inc.)

☐ Please send me the complete brochure on this course

MAIL TO: Registrar, IC Design Course TIC 97MR3
Motorola Semiconductor Products Inc.
Box 955 • Phoenix, Arizona 85001

Motorola reserves the right to limit enrollment.


FOR VALUE
EVALUATE SPERRY
Transportable...
rapid setup...
all-weather...
multi-mission...

Tactical 3-D Radar. AN/TPS-34 by Sperry—among the latest tactical air defense systems—is being delivered to the U. S. Marine Corps, and has been selected by the British Ministry of Aviation for use by the Royal Air Force. A three-dimension radar, it is light in weight and transportable by land, sea and air. The TPS-34 employs two simple fan-beams (producing a V-beam) to obtain total volume coverage — providing accurate range, bearing and altitude data — for all targets. Its high tactical mobility, service ruggedness and all-weather reliability suit it ideally to military requirements of rapid set-up and breakdown. Electronically advanced — with modern ECCM systems — the TPS-34 is easily adaptable to a wide variety of missions. *RADIATION DIVISION, Sperry Gyroscope Company, Great Neck, New York.*

SPERRY
DIVISION OF
SPERRY RAND
CORPORATION

Circle No. 6 on Subscriber Service Card

Mergers and Acquisitions

The J. A. Maurer Co., Long Island, N.Y., has purchased Abrams Instrument Corp., Lansing, Mich., from the Curtiss-Wright Corp., which had Abrams as a subsidiary for about three years. Abrams manufactures electronic instruments for space and airborne applications. Maurer specializes in producing aerial cameras and 35-mm motion picture cameras and equipment as well as making electronic instruments and aerial navigation equipment. . . . *Electronic Specialty Co., Los Angeles, and R. H. Osbrink, Inc., have consolidated for an undisclosed number of shares of ESC stock. Osbrink produces magnesium sand castings; ESC makes electronic and electromechanical devices.* . . . Latronics Corp., Latrobe, Pa., has purchased from BG Corp., Ridgefield, N.J., BG's line of commercial and military alumina terminals and bushings. These products will be made by Latrobe's Ceramic Seals Div. and will be offered as standard shelf items, supplementing the Latronics line of custom metalized ceramic seals. . . . *Ampex Corp., Redwood City, Calif., has formally acquired Mandrel Industries, Inc., a Houston, Tex., manufacturing and geophysical service company, as a subsidiary. Shareholders of both companies have agreed to the proposed exchange of 10 shares of Mandrel stock for nine of Ampex.*

New Activities

Litton Industries, Inc., has formed a new division with headquarters in Rochester, N.Y. The Amecom Div. consists of the old Adler-Westrex Communications, Emertron and McKiernan-Terry Marine divisions. Amecom is intended to increase LI's systems activities in communications, electronic countermeasures, oceanography and information and control.

Honeywell Seeks Name Change

Minneapolis-Honeywell Regulator Co. on April 28 will ask stockholders' approval of a planned name change to Honeywell, Inc. The firm feels the old name implies a capability restriction that no longer exists in the company. The shorter name has been in common use for some time anyway. The firm merely wants to make it official.

In The Courts

A majority of the unsecured creditors of CompuDyne Corp., a Hatboro, Pa., electronics firm, approved a plan for settlement of claims in Philadelphia Federal district court. The firm had filed for court protection last May under the Federal Bankruptcy Act. The plan provides for settlement of Class 1 claims for 10% in cash and the balance in a new issue of preferred stock. Class 2 claims would be settled by issue of the new stock.

New Facilities

Sylvania Electric Products, Inc., has announced plans for a 60,000-sq.-ft. expansion of its facilities in Mountain View, Calif. Two new wings will be added to the firm's existing building to accommodate research and development work in electronic warfare, reconnaissance and security systems. Completion is expected by late 1964. . . . *Trans-World Airways, recently named supplier for base services at NASA's Merritt Island Launch Area, has opened an office in Cocoa Beach, Fla. R. W. Wilson is in charge of the new Base Operations Support Services Div. of TWA.* . . . Nanmac Corp., Indian Head, Md., manufacturers of ablating thermocouples, has moved its main plant and offices to Needham Heights, Mass. . . . *The Institute for Scientific Information has moved its headquarters to 4th & Chestnut Streets, Philadelphia. The new facility more than doubles the organization's previous space.* . . . National Semiconductor Corp. is transferring all activities of its Clark Semiconductor Div. to the firm's new main plant and headquarters in Danbury, Conn. Clark, manufacturer of silicon power transistors for telemetry and other communications applications, was formerly located in Clark, N.J. . . . *Ling-Temco-Vought, Inc.'s Ling Electronics Div. has equipped a new vibration laboratory in Canoga Park, Calif., for Rocketdyne Div. of North American Aviation, Inc. The facility is being used to subject components of space rockets to the vibration stresses that will be experienced during take-off and space flight. The equipment includes a shaker, an electronic amplifier and extensive instrumentation for controlling and monitoring vibration tests.*

Company Representatives

Applied Engineering Products Co., Stamford, Conn., has named two West Coast representatives for its line of minature RF coaxial connectors. McDonald Associates, Santa Monica, Calif., will cover the Pacific southwest; Cascade Marketing Co., Everett, Wash., will handle the Pacific northwest. . . . *Twin Industries Corp., Buffalo, N.Y., has appointed Airsupply Co., Beverly Hills, Calif., sales and engineering representative. Airsupply, a division of Garrett Corp., will handle TIC's line of missile structure components, ground support and other missile/space equipment.* . . . Carter-Princeton, an electronics division of Carter Products, Inc., in Princeton, N.J., has named the Dave Miller Sales Co., Inc., Seattle, as sales representative in the northwestern U.S. and part of Canada. C-P designs and manufactures thermoelectric devices. . . . *Hitchiner Manufacturing Co., Inc., Milford, N.H., has appointed Martin J. Scanlon Co., Detroit, Mich., sales representative for Hitchiner and its subsidiary, Delta Microwave, Hackensack, N.J. Scanlon will represent both firms' lines of investment castings in Michigan.*

Miscellaneous

The Boeing Co. annual report reflects a 1963 missile/space sales figure over twice as great as that for military aircraft. Sales in the missile/space category totaled $1,033,000,000. Military aircraft accounted for $477,000,000; commercial aircraft, $261,000,000.

contracts and procurements

AWARDS

AIR FORCE

$42,200,000—**International Business Machines Corp.,** Endicott, N.Y., for purchase of formerly leased electronic data processing equipment.

$13,200,000—**Federal Electric Corp.,** Paramus, N.J., for field engineering services related to work at the Pacific Missile Range.

$12,400,000—**Avco Corp.,** Stratford, Conn., for production of Mark IIA re-entry vehicles for ICBMs.

$4,000,000—**Kollsman Instrument Corp.,** Elmhurst, N.Y., for geodetic and surveying systems.

$3,400,000—**Control Data Corp.,** Minneapolis, for purchase of formerly leased automatic data processing equipment.

$1,500,000—**North American Aviation, Inc., Autonetics Div.,** Anaheim, Calif., for guidance and control equipment related to *Minuteman* ICBMs.

$1,500,000—**Sylvania Electric Products, Inc.,** Mountain View, Calif., for antenna groups and electronic receiving sets.

$1,500,000—**General Electric Co.,** Syracuse, N.Y., for Pacific Missile Range test operations.

$191,500—**Ling-Temco-Vought, Inc.,** Dallas, for a study of insulative heat shield attachment systems.

$77,000—**President and Fellows of Harvard College,** Cambridge, Mass., for solar research.

$44,627—**Collins Radio Co.,** Cedar Rapids, Iowa, for pre-programmed ground antenna tracking equipment.

$27,534—**Regents of the University of California,** Berkeley, Calif., for research and reports on subconvulsive effects of UDMH propellant on the nervous system.

ARMY

$70,607,900—**Western Electric Co.,** New York City, for continued research and development of the *Nike-X* antiballistic missile.

$4,900,000—**Sperry Rand Corp.,** Great Neck, N.Y., for work on classified electronic equipment.

$2,500,000—**Melpar, Inc.,** Falls Church, Va., for chemical agent warning and detection studies.

$1,730,800—**Murray J. Shiff Construction Co.,** Compton, Calif., for construction of a booster assembly building at Edwards AFB, Calif.

$1,300,000—**Chicago Bridge and Iron Co.,** South Pasadena, Calif., for the construction of a space simulation facility for testing orbital control rocket engines.

$91,936—**Pan American Airways, Inc.,** Tucson, Ariz., for security and maintenance of a universal target missile tracking system.

$29,640—**Western Electric Co.,** Whippany, N.J., for further research and development on the *Nike-X* program.

NAVY

$12,100,000—**General Dynamics Corp.,** Pomona, Calif., division, for guidance control equipment for *Terrier* and *Tartar* air defense missiles.

$6,100,000—**Goodyear Tire and Rubber Co.,** Akron, Ohio, for production of *Subroc* missiles.

$4,300,000—**North American Aviation, Inc.,** Columbus, Ohio, for further production of *Sparrow III* rocket motors.

$1,500,000—**Computer Measurements Co.,** San Fernando, Calif., for the design and production of electronic counters.

$470,000—**Varian Associates,** Palo Alto, Calif., for microwave tubes.

$74,656—**Hughes Aircraft Corp.,** Fullerton, Calif., for research in the basic mechanisms of transient radiation.

$64,414—**Dunlap and Associates, Inc.,** Darien, Conn., for operations application study of the critical manning problem for the 41-boat *Polaris* fleet.

NASA

$16,400,000—**Chrysler Corp., Space Div.,** Michoud, La., for modifications and additional support services related to *Saturn I* and *IB* production. Work will be performed at Michoud, Marshall Space Flight Center, Huntsville and Cape Kennedy (three contracts).

$190,000—**General Dynamics/Electronics,** Rochester, N.Y., for space tracking equipment.

$97,227—**Ithaco, Inc.,** Ithaca, N.Y., for a design study and breadboard signal processor for *Nimbus* spacecraft.

$94,913—**Hewlett-Packard Co.,** Palo Alto, Calif., for counter and converter-time measurement equipment.

$85,384—**TRW-Space Technology Laboratories, Inc.,** Redondo Beach, Calif., for a study of a gravity gradient stabilized *Nimbus* spacecraft.

$60,336—**Hittman Associates, Inc.,** Baltimore, Md., for a study of thermoelectric power conversion.

$52,825—**General Dynamics Corp., General Atomic Div.,** San Diego, for research on the determination of rare earth abundances in meteorites.

$51,570—**Control Data Corp.,** Minneapolis, Minn., for a *Nimbus* automatic programming system.

$51,300—**Radio Corp. of America, Electron Tube Div.,** Lancaster, Pa., for a fundamental study of radiation resistant silicon.

$50,000—**California Computer Products, Inc.,** Anaheim, Calif., for a reliability assessment study for the *Nimbus* command clock system.

$36,280—**Control Research Associates Co.,** Laurel, Md., for system and component analysis for the *Aerobee* rocket attitude control and despin control system.

$25,699—**Tektronics, Inc.,** Annandale, Va., for oscilloscopes and related accessories.

Harshaw Chemical Co., Cleveland, for the production of a quantity of cadium sulfide solar cells (undisclosed amount).

Computer Dynamics Corp., Silver Spring, Md., for provision of data processing services in support of NASA's computer facility (undisclosed amount).

DOD

$500,000—**Cubic Corp.,** San Diego, for follow-on work related to a classified DOD program covering angle and distance measuring equipment to determine position and number of airborne objects simultaneously.

DEFENSE COMMUNICATIONS AGENCY

$3,400,000—**Western Union Telegraph Co.,** for installing digital communications equipment at Larsen AFB, Wash., and Hancock Field, Syracuse, N.Y.

WEATHER BUREAU

General Precision, Inc., Link Div., Binghamton, N.Y., for design, development and production of the Satellite Digital and Analog Display System (SDAD) related to retrieval and analysis of data gained from orbiting weather satellites (undisclosed amount).

INDUSTRY

$1,000,000—**Beckman Instruments, Inc.,** Fullerton, Calif., from **Grumman Aircraft Engr. Co.,** for a data acquisition system to be used in testing for the lunar excursion module.

$1,000,000—**Fluor Corp.,** Los Angeles, from **General Dynamics Corp.,** for work related to *Centaur* launch facilities at Cape Kennedy.

$600,000—**Consolidated Electrodynamics Corp.,** Pasadena, Calif., from **Douglas Aircraft's Missile and Space Systems Div.,** for pre-detection magnetic tape recorders and oscillographs for use in the *Saturn* S-IVB booster program.

$230,000—**Paul Chemical Co.,** Buena Park, Calif., from **TRW Space Technology Laboratories,** for design, fabrication and installation of a cryogenic nitrogen and oxygen storage, transfer and vaporization facility for the San Juan Capistrano rocket engine test facility.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

National Aeronautics and Space Administration
Washington, D.C.

Study of the stresses and strains in birefringent material in the elastic and plastic range. NASA is negotiating a contract with Douglas Missile and Space Systems Div., Douglas Aircraft Co., Inc., Santa Monica, Calif. No RFP available. For information only.

Purchasing Office
Marshall Space Flight Center
Huntsville, Ala.

Vibration testing of *Saturn V* instrument mounting components including brackets, panels and vibration isolation systems. Design and fabrication of test fixtures is required. Test specimen will be Government-furnished and will weigh between 5 and 500 lbs. Maximum test specimen and fixture weight is 1,000 lbs. Offerer's geographic location will be an evaluation factor for award. Period of performance is 12 months. RFP 1-4-50-01107-01. Requests for the above RFP should be forwarded to the above office, Attn: J. J. Pirkle. Phone: 534-7922.

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Virginia

NASA Langley Research Center is negotiating a contract with Electro-Optical Systems, Inc., Pasadena, Calif., covering theoretical studies and laboratory experimentation in an evaluation of critical factors related to a flight experiment for reflective surface samples. This notice is for information only. RFP L-4196 not available.

National Aeronautics and
Space Administration
Manned Spacecraft Center
General Research Branch
Facilities Section (ACB)
Houston, Tex.

Negotiations will be conducted with Texas Center for research in applied mathematics and mechanics, 4403, Coventry Lane, Austin, Tex. Study for optimum methods for determining and predicting spare vehicle trajectories. Contract will result from an unsolicited proposal from contractor. RFP not available. PR No. 4500812. It is suggested that small business firms and others interested in subcontract opportunities make direct contact with the above firm.

Nationad Aeronautics and
Space Administration
Contracts Div.
Washington, D.C.
Attn: F. C. Weirich
Phone: WO 2-0268

Study of differential bremstrahlung cross-sections for unpolarized incident electrons and positions. NASA is negotiating with Union Carbide Corp., 270 Park Ave., New York City; based on an unsolicited proposal. For information only.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio

NASA Lewis Research Center is soliciting proposals to perform the investigation of oxide and hydroxide forms as they form in a sealed nickel cadmium cell. RFP SPSD-1135. For further information contact Tom Donohue, Area Code 216, 433-4000, Ext. 551.

Negotiations will be conducted with Radio Corp. of America, David Sarnoff Research Center, Princeton, N.J., for research on vapor filled thermionic converters. P/R SPSD-1164. Note: For information only; RFP not available.

Nike-X Project Office
Army Materiel Command
Redstone Arsenal, Ala.

The Nike-X Project Office, through the Army Missile Support Command, proposes to supplement a contract with Lockheed Propulsion Co., P.O. Box 111, Redlands, Calif., for an additional R&D effort in continuation of the Sprint propellant back-up program. It is suggested that small business firms and others interested in subcontracting opportunities make direct contact with the above firm.

The Nike-X Project Office, through the New York Procurement District, proposes to supplement a contract with Western Electric Co., 222 Broadway, New York City, to provide additional services in support of the *Nike-X* program. Competition is precluded because of the continuing nature of the services. It is suggested that small business firms and others interested in subcontracting opportunities make direct contact with the above firm.

Contracting Officer
National Aeronautics and
Space Administration
Langley Station
Hampton, Virginia

Sole source supplier. Negotiations will be conducted with the Avco Corp., Wilmington, Mass., for the fabrication of two nosecap assemblies to be coated with Avco-developed ablation material. RFP L-4303. For information only. No RFP available.

National Aeronautics and
Space Administration
Washington, D.C.

NASA is negotiating a contract with Moore-Peterson Associates, Washington, D.C., for a survey-study of the interconnection problem in microelectronics. No RFP available. For information only.

National Aeronautics and
Space Administration
Manned Spacecraft Center
General Research Procurement Office
Houston, Tex.
Attn: Darly W. Chilcutt
Area Code 713, WA 8-2811, Ext. 7351

Negotiations will be conducted with Dynamics Research Corp., 38 Montvale Ave., Stoneham, Mass., for a digital shaft encoder and modification to existing contract NAS 9-12-63. RFP 64-996P. Note: For information only; no RFP available.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Ala.

Formulation of space environment criteria; RFQ 1-4-75-01037-01. RFQ due date 3-20-64. It is estimated that 12 months will be required to complete this study.

Analysis of flight failure data to predict safety factors of man-rated systems. RFQ 1-4-60-01010-01. Period of performance shall be for 11 months from date of any resultant contract; 10 months for completion of work plus one month for preparation and submission of summary report.

High resolution wind measuring system study. RFQ 1-4-75-01041-01. RFQ due date 3-24-64. It is estimated that the period of performance shall be approximately 12 months; 11 months for completion of work, and one month for preparation, submission and approval of final technical summary report.

National Aeronautics and
Space Administration
Manned Spacecraft Center
General Research Procurement Office
Houston, Tex.
Attn: Aubin O. Ferguson
Phone: Area Code 713, HU 3-5441

Design and fabrication of a 14-channel tape transport with direct, FM and PDM record reproduce modules. RFP MSC 64-1075P.

National Aeronautics and
Space Administration
Ames Research Center
Moffett Field, Calif.

Negotiations will be conducted with the General Electric Co., Philadelphia, for a study of gravity gradient rods. RFP A-8065. Note: For information only. No RFP available.

National Aeronautics and
Space Administration
Flight Research Center
P.O. Box 273
Edwards AFB, Calif.

Research and development contract is being negotiated with Spacelabs, Inc., to establish design parameters for a biogrid with system to measure surface biopontials of the human body. Contract is resultant from an unsolicited proposal. This synopsis is for information only and no other proposals will be considered.

Picatinny Arsenal
Dover, N.J.

Adapter, connector, tee, coaxial in accordance with Dwg. 8864789—850 each. Connector, plug, R.F. coaxial, right angle, in accordance with Dwg. 8863276—460 each. IFB 64-331B. Bid opening 3-23-64. Bid sets and specs available at all Procurement Districts.

Directorate, Procurement and Production
Middletown Air Materiel Area
Olmsted AFB, Pa.

S/N 1450-075-2117AA, frame, missile loading and handling, IAW Air Force Dwg. 63F22229. Application: AIM-4A/B/C/D-181 each. Preproduction sample testing requirement of first unit. Deliveries to Olmsted AFB, Pa. IFB 36-600-64-379. Bid opening 3-27-64. Direct inquiries to Wright Inn, MAPODA, r44-5521, Ext. 6209.

engineers • scientists

NEW CAREER POSITIONS

at Fast Moving
Atlantic Research Corporation

The continued expansion at Atlantic Research Corporation has created several new career opportunities in the Washington, D.C. area, including the following:

DEVELOPMENT PROJECT ENGINEER

To plan and direct challenging programs in area of solid propellant development and evaluation. Requires knowledge of theoretical performance analysis combustion characteristics, laboratory and pilot plant processing, internal ballistics and static firing evaluation. Applicant should offer creativity, technical writing ability and supervisory skill. M.S. or Ph.D. in chemical engineering with 1 to 5 years applicable experience.

PROJECT ENGINEER

To assume overall production management of Arcas Sounding Rocket System. Responsibilities include: Production customer liaison; production program management and coordination; resources management; production planning, scheduling, and monitoring; budgeting, cost control, and reporting; and proposals and costing. Requires B.S. or M.S. engineering with two years minimum experience (emphasis on production oriented training and/or experience).

STAFF ENGINEER
(Technical Surveillance)

To assume responsibilities for technical surveillance and trouble shooting of rocket manufacturing operations including inert (metal and plastic) components, solid propellant grains and motor assemblies on a major tactical motor production program. Includes field service, value engineering, technical product engineering responsibilities. Requires B.S. chemical or mechanical engineering, with minimum of 5 years applicable experience.

PROPULSION DESIGN ENGINEER

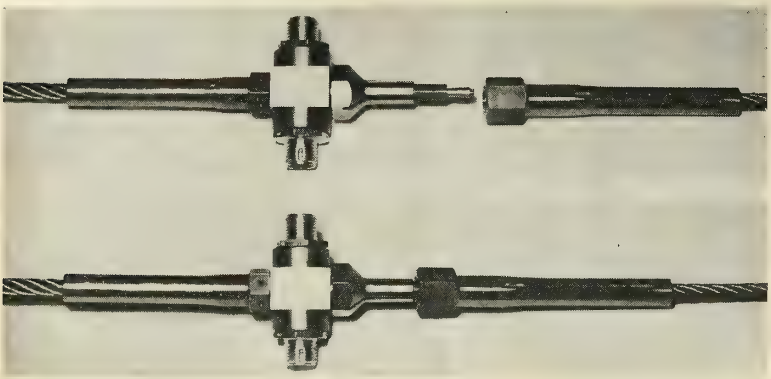
Provide specialized design and/or analytical support for proposed or existing rocket motor development programs. Duties include rocket or vehicle optimization studies, definition of propellant and hardware requirements, grain design, internal ballistics, transient heat transfer analyses, elementary stress analyses, design of filament wound motor cases, advanced nozzle design, and miscellaneous design and analytical studies. B.S. engineering, physics, or mathematics; three to five years diversified experience in rocket development field. Requires good mathematical background, and familiarity with computer techniques.

Send resume to: Director,
Professional Personnel, Dept. 429

Atlantic Research
CORPORATION
Alexandria, Virginia
(A residential suburb
of Washington, D.C.)

An equal opportunity employer

Circle No. 2 on Subscriber Service Card



New Product of the Week: Non-Fragmented Separation Device

A separation device that can function as a conventional threaded fastener and then release members immediately upon command without producing loose parts, fragments or applying thrust to the separating members is available from Harvey Aluminum.

Controlled thrust can be applied if required. Gaseous contamination is eliminated since the system is completely sealed. Tensile capacity in the ⅜-in. size is 8,000 lbs. and each unit is tested to 6,000 lbs. before shipment.

Applicable documents covering the unit are military specifications MIL-E-5272E, MIL-I-6866-A, MIL-I-6868B, MIL-D-70327(2) and military standards MIL-STD-130B, MIL-STD-101B, MIL-STD-300 series and MS-21260A.

Circle No. 151 on Subscriber Service Card

Drift Detector

Technical Measurement Corp. is marketing a solid-state lithium drift detector with a 1-in. diameter.

The unit has a sensitive area of 500 sq. mm. and is available with depletion depths of ½, 1, 2 and 3 mm. The 2-mm. detector has a resolution exceeding 35 kev FWHM at room temperatures. Better than 10 kev FWHM is guaranteed at dry ice temperatures.

Circle No. 152 on Subscriber Service Card

Hydraulic Gear Pump

A line of hydraulic gear pumps and motors in modular design is available from Fluid Power Div. of Aurora Corp. of Illinois.

The units will handle optional port locations, have interchangeable mounting flanges and are available with clockwise or counterclockwise rotation. The aluminum pumps will operate at 2,000 psi and 2,000 rpm with maximum continuous operation at 2,500 rpm. Maximum intermittent operation speed is 2,700 rpm. The motors are rated at a maximum continuous speed of 2,000 rpm, maximum continuous pressure of 2,000 psi, clockwise or counterclockwise.

Circle No. 153 on Subscriber Service Card

Electrometer

Applied Physics Corp. has developed a vibrating reed electrometer designed specifically for space exploration.

The instrument can be used to measure solar winds and currents as small as 5 x 10^{-15} amperes. It has an output drift of 0.1 mv per day, non-cumulative at constant temperatures. Response is 1 sec., critically damped (98.6%); linear range is 10^{-9} to 5 x 10^{-16} amps with one range change, utilizing a 5 x 10^{9} and a 10^{12} ohm resistor. Accuracy is ±1% full scale. The device has a power requirement of 1 watt or less from an 18-v power supply; output is 0 to ±5v on each range.

Circle No. 154 on Subscriber Service Card

Digital Tape Programmer

Lundy Electronics & Systems, Inc., has developed a universal digital tape programmer capable of unattended programming of several hundred thousand unique events over a period of more than 2 years.

The multi-channel device punches the program in binary code on 0.002-in. thick mylar tape and transfers it to a ferrite core bit organized magnetic memory for sequential readout. Interrogation rate is determined by the required resolution of the programmer; type of clock rate generator is determined by the long-term accuracy required. A 0.00001% error is attainable using crystals in a temperature-controlled environment. Atomic clocks permit accuracy of one part in 10^{11}.

Circle No. 155 on Subscriber Service Card

Oscillator

Scionics Corp. is marketing the Model 159 solid-state voltage controlled oscillator, designed for spaceborne applications.

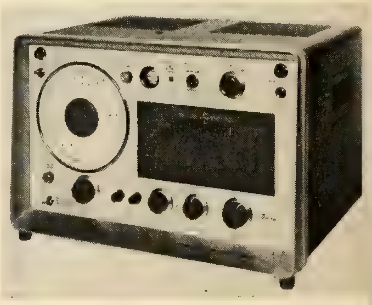
The device has an operational temperature range of 0° to 185°F with frequency shift less than 1% of DBW per 100°F. Input impedance for channels 1 to 18 is 500 k ohms, and channels A to E is 250 k ohms. Distortion is less than 1% harmonic at center frequency. Input voltage is 0 to 5v dc or ±2.5v dc. Output voltage is adjustable to 1.0v RMS maximum.

Circle No. 156 on Subscriber Service Card

VLF Function Generator

A VLF function generator capable of generating any wave shape, provided it is a single-valued function and repetitive, has been developed by Houston Instrument Corp.

In the Model SG-88, the conventional oscillator circuit is replaced by a rotating transparent disc scanned by a narrow light beam. Silk-screened on each disc is an opaque pattern representing in polar coordinates the waveform to be produced. The light beam passes through the transparent areas and is deflected onto a photoelectric transistor by a spherical mirror. Frequency and intensity of the light signal establishes the electronic signal to produce the desired output waveform.



Output frequency range is 0.005 to 50 cps. DC voltage levels at output terminals can be set between ±25v from ground level. The waveform (at 40 cps) and output voltage level can be monitored by a built-in oscilloscope.

Circle No. 157 on Subscriber Service Card

Octave C-Band Circulator

An octave bandwidth circulator covering the 4.0 to 8.0-gc range is being marketed by Western Microwave Laboratories, Inc.

The Model CC-48 has a 20-db minimum isolation and an insertion loss of 0.4 db maximum. VSWR is 1.25:1 maximum. With TNC female connectors in Y configuration, the device measures 2¼ in. in diameter and 1¼ in. thick.

Circle No. 158 on Subscriber Service Card

Pile Oscillator

The Model 301 pile oscillator for use in research reactors for conducting frequency response analyses is being marketed by Reactor Experiments, Inc.

The device can be designed for use in either vertical or horizontal access positions and can operate over a range of reactivity cycles from about 0.002 to 120 cps. It has been operated with shafts up to 35 ft. long.

Circle No. 159 on Subscriber Service Card

Beam Power Tube

An all-glass twin tetrode transmitting tube that operates up to 600 mc is available from Tung-Sol Electric, Inc.

The Type 6907 is designed for both fixed station and mobile transmitting applications. As an RF amplifier at 150 mc, the unit will handle 90 watts input with 20 watts total plate dissipation. It is rated for 6.3 or 12.6 heater volts and exhibits natural cooling with a plate voltage of 300v at frequencies up to 470 mc. Bulb temperature is 250°C.

Circle No. 160 on Subscriber Service Card

Bridge Rectifier

A full-wave bridge rectifier for use n high-frequency power supplies is being marketed by TRW Semiconductors.

The Model PS3383 is a 3-kv unit and will handle 50-kc sine wave input at 175 ma average rectified current into a capacitive load. At 100 kc, it will handle 70 ma.

Circle No. 161 on Subscriber Service Card

X-Band TWT

An X-band, helix traveling wave ube with periodic permanent magnet ocusing has been introduced by Rayheon Co.

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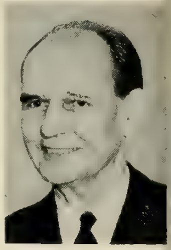
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Robert W. Laffin: Elected vice president of manufacturing for Simmonds Precision Products, Inc., Tarrytown, N.Y.

William D. Wilson: Appointed manager of the office of public information for Radiation, Inc., Melbourne, Fla.

Robert L. Wells: Elected vice president-engineering for Westinghouse Electric Corp., Pittsburgh.

James B. Hall: Appointed chief of the ordnance systems applications engineering group at the Anaheim, Calif., facility of Northrop Corp.'s Nortronics Div.

Charles J. Merrill: Elected a vice president of The Matrix Corp., Arlington, Va.

Alfred Strogoff: Named president of the newly formed Amecom Div. of Litton Industries, New Rochelle, N.Y.

Philip S. Devirian, Jr.: Named manager of international engineering and production for FMC Corp.'s Ordnance Div., San Jose, Calif.

Merle J. Ackerman: Joined Houston Instrument Corp., Bellaire, Tex., as general sales manager.

Leonard H. Eisner: Appointed international marketing manager of Computer Control Co., Inc., Framingham, Mass.

Gen. Paul M. V. Stehlin: Former chief of staff of the French Air Force, joined Hughes Aircraft International Service Co., Paris, as vice president of advanced planning.

Dr. Edward L. Ginzton: Elected chairman of the board and president of Varian Associates, Palo Alto, Calif.

George Eisler: Appointed executive vice president of Scientific Data Systems, Inc., Santa Monica, Calif. **Peter Fenchel** appointed vice president-finance.

R. J. Rutherford: Elected a vice president of Vapor Corp., Chicago.

D. B. Morrissett: Joined the staff of Computer Systems, Inc., Richmond, Va., as executive vice president and member of the board of directors.

Frederick J. Bendetti: Named head, environmental criteria section of the Design Analysis Dept., Aeromechanics Subdivision, San Bernardino, Calif., Operations of the Aerospace Corp. **William S. Vance** named associate department head, Design Analysis Dept.

Jack M. Beauchamp: Appointed assistant to senior vice president at Aerojet-General Corp., El Monte, Calif.

John Messerschmitt: Promoted to vice president-general manager, Tube Div., Amperex Electronic Corp., Hicksville, N.Y.

A. L. Wallace, Jr.: Named program director of North American Aviation's Space and Informations Systems Div.'s Project Cloud Gap headquartered in Washington, D.C.

Brian Hooper: Joined LTV Ling Electronics Div. of Ling-Temco-Vought, Inc., Anaheim, Calif., as chief engineer-high power electronics.

Dr. Charles A. Berry, M.D.: Appointed chief of center medical programs for the NASA Manned Spacecraft Center, Houston.

Frank H. Bower: Joined Raytheon Co.'s Semiconductor Div., Mountain View, Calif., as manager of microelectronic manufacturing.

William R. Backer: Appointed chief engineer, research and design, at Norton Co.'s Machine Tool Div., Worcester, Mass.

Dr. Aaron A. Levin: Named a project manager for Diffraction Limited, Inc., Bedford, Mass.

John H. O'Neill: Appointed manager of engineering for Semicon Associates, Inc., Lexington, Ky.

James D. Harlin: Named sales manager of Electronic Research Co., Overland Park, Kan.

William D. Hambrook: Appointed manager of purchasing at Standard Pressed Steel Co., Jenkintown, Pa.

Thomas J. Connors: Named vice president and general manager of Motorola Semiconductor Products Inc., Phoenix, Ariz.

when and where

MARCH

Society for Nondestructive Testing Spring National Convention, Chapman-Park Hotel, Los Angeles, Mar. 16-19.

Pricing and Negotiating Prime and Subcontracts in the Defense and Aerospace Industries Seminar, sponsored by the Contract Management Institute, Ambassador Hotel, Los Angeles, Mar. 16-20.

NBS Symposium on Statistical Association Methods for Mechanized Documentation, National Bureau of Standards, Washington, D.C., Mar. 17-19.

Third Hypervelocity Techniques Symposium, Denver, Colo., Mar. 17-18.

Second Semi-Annual Air Force RTD Procurement Management Seminar, Del Mar Hotel, Santa Monica, Calif., Mar. 18-20.

IEEE International Convention, Hilton Hotel and Coliseum, New York City, Mar. 23-26.

American Meteorological Society National Conference on Physics and Dynamics of Clouds, University of Chicago, Mar. 24-26.

Southwest Research Institute Aerospace Bearing Conference, San Antonio, Tex., Mar. 25-27.

Technical Symposium, sponsored by Polytechnic Institute of Brooklyn, IRE, AIEE, Army, Navy and Air Force, New York City, Mar. 23-Apr. 2.

American Society for Test and Materials, Pyrolytic Graphite Symposium, Palm Springs, Calif., Mar. 30-31.

APRIL

Society of Plastics Engineers, Engineering with Thermoplastics, Sheraton Hotel, Akron, Ohio, Apr. 1.

Worcester Polytechnic Institute, Annual Scientific Briefing for Tomorrow, Worcester, Mass., Apr. 1.

Optical Society of America Spring Meeting, Sheraton-Park Hotel, Washington, D.C., Apr. 1-3.

AIAA Annual Structures and Materials Conference, Riviera Hotel, Palm Springs, Calif., Apr. 1-3.

American Chemical Society National Meeting, Philadelphia, Apr. 5-10.

22nd Annual Meeting, National Aerospace Services Association, International Inn, Washington, D.C., Apr. 6-7.

IEEE Rubber and Plastics Industry Conference, Sheraton-Mayflower Hotel, Akron, Ohio, Apr. 6-7.

Solar Energy Symposium, University of Florida, Gainesville, Apr. 6-7.

Pricing and Negotiating Prime and Subcontracts in the Defense and Aerospace Industries Seminar, sponsored by the Contract Management Institute, Palmer House, Chicago, Apr. 6-10.

IEEE International Conference on Nonlinear Magnetics, Shoreham Hotel, Washington, D.C., Apr. 6-8.

ASME Design Engineering Conference and Show, McCormick Place, Chicago, Apr. 6-9.

ISA Measurement and Control Instrumentation Div. Symposium, Floridian Hotel, Tampa, Apr. 8-10.

48th Annual Meeting, Federation of American Societies for Experimental Biology, Conrad Hilton Hotel, Chicago, Apri. 12-18.

IEEE Symposium on Microelectronics, Chase-Park Plaza Hotel, St. Louis, Apr. 13-15.

Institute of Environmental Sciences, Annual Technical Meeting and Equipment Exposition, Sheraton Hotel, Philadelphia, Apr. 13-15.

American Power Conference, sponsored by IEEE and Illinois Institute of Technology, Sherman Hotel, Chicago, Apr. 14-16.

IEEE and ASME International Conference and Exhibit on Aerospace Electro-Technology, Westward-Ho Hotel, Phoenix, Ariz., Apr. 19-25.

ASTME Annual Meeting, Convention and Exposition, Detroit, Apr. 20-24.

Seminar on Nonlinear Partial Differential Equations in Mathematical Physics, sponsored by Air Force Office of Scientific Research, Army Research Office, and American Mathematical Society, Hotel New Yorker, New York City, Apr. 20-23.

AFIPS, IEEE and ACM Spring Joint Computer Conference, Sheraton-Park Hotel, Washington, D.C., Apr. 21-23.

IEEE Southwest Conference and Electronics Show, Dallas Memorial Auditorium, Dallas, Apr. 22-24.

American Geophysical Union, Annual National Meeting, Washington, D.C., Apr. 22-25.

Fourth Rare-Earth Research Conference, sponsored by AF Office of Scientific Research, Phoenix, Ariz., Apr. 22-25.

National Aeronautics Meeting and Production Forum, sponsored by SAE and ASME, Commodore Hotel, New York City, Apr. 27-30.

MAY

American Society for Microbiology, Sheraton Park and Shoreham Hotels, Washington, D.C., May 3-7.

10th National Aerospace Instrumentation Symposium sponsored by ISA, Biltmore Hotel, New York City, May 4-6.

AIAA Aerospace Propulsion Meeting, Cleveland, May 4-6 (semi-classified).

10th Annual Meeting of the American Astronautical Society, Hilton Hotel, New York City, May 4-7.

ASME Metals Engineering Conference, Sheraton-Cadillac Hotel, Detroit, Mich., May 4-8.

Fifth National Symposium on Human Factors in Electronics, sponsored by IEEE-HFE, San Diego, Calif., May 5-6.

IEEE-EIA Electronic Components Conference, Marriott Twin Bridges Motor Hotel, Washington, D.C., May 5-7.

Society for Experimental Stress Analysis Spring Meeting, Hotel Utah and Motor Lodge, Salt Lake City, May 6-8.

Acoustical Society of America Spring Meeting, Hotel New Yorker, New York City, May 6-9.

COSPAR Seventh Plenary Meeting, Florence, Italy, May 8-20.

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Hogwash in Harper's

PRESIDENT EISENHOWER, who should have known better, left this industry an undeserved and evil legacy with his valedictory warning that the nation should beware of the power of the "military-industrial complex."

It is dragged out, dusted off and trumpeted loudly whenever someone wishes to attack the industry and the military, both of which have done and are doing a conscientious job of keeping U.S. military strength at a level second to none.

The latest to latch onto this old saw is *Harper's* magazine, which in its March issue offers the first of a three-part series by Julius Duscha, a political reporter for the *Washington Post*. This article, illustrated on the cover with symbolic missiles, is entitled "Arms and the Big Money Men: Congressmen, Contractors, and the 'Defense' Pork Barrel."

The article is so biased and ill-informed that we wonder why *Harper's* has undertaken to print the series, which falls right into line with the recent series of movies slandering our military effort. The bias is evident in the very wording. There are references to that fact that defense "eats up" more than half of the Federal budget, to "phalanxes" of lobbying Air Force officers, "lavish" conventions, and "luxurious" military aircraft.

We will let Mr. Duscha himself enlighten you on the terrible things that are going on:

"Defense budgets increase, the services promote their favorite projects among contractors and their friends on Capitol Hill, the politicians try to advance their careers by announcing and sometimes influencing the awarding of defense contracts, the White House continues to take an avid interest in seeing that Democrats get the maximum political mileage out of defense spending, the services butter up their pals on Capitol Hill with bases in their states as well as brandy—and big contracts as well as black cigars—and officers move off active duty onto retirement lists and into jobs with contractors that, during their Pentagon days, they were supposed to hold at arms' length."

No one has been more critical of questionable industry practices than this magazine. We have, for example, in the past taken sharp issue with some of the very things Mr. Duscha mentions—"lavish" conventions by the military associations ("On Booze, Blondes and Bashes," M/R, Oct. 23, 1961, p. 50), the continuation of unnecessary programs ("The Meaning of *Skybolt*," M/R, Jan. 7, 1962, p. 54), employment by the industry of retired officers as lobbyists ("Conflict of Interest," M/R, Feb. 18, 1963, p. 50) and political influence on defense spending ("Politics and Procurement," M/R, March 4, 1963, p. 58).

Probably Mr. Duscha would regard us as a "mouthpiece" for the industry. Nevertheless, we believe the above list is evidence of our own firm belief that questionable industry practices should be publicly criticized.

We also believe, however, that such criticism should be objective and that it should be on the basis of fair and accurate reporting of facts. Mr. Duscha is so little familiar with the industry he attacks that he does not even get his facts right.

He refers to the Aeronutronics Division of Philco Corp., Ford subsidiary, as Ford's Aeronautical Division and to Douglas Aircraft Co. as Douglas Corp.

He tells us: "Not since the country's isolationist days of the 1930's has Congress questioned the need for ever-increasing defense expenditures—in time of peace as well as war."

He quotes a Missouri Congressman (Republican Thomas B. Curtis) as telling him: "The Armed Services Committees are a patsy for the Pentagon." Mr. Duscha adds that the Senate and House Appropriations subcommittees are just as sympathetic toward the military as are the Armed Services Committees. He builds a fascinating case that all of this is due to the fact that defense contracts mean votes back home and that the services have their way on the Hill because they ply Congressmen with cocktail parties, steak dinners, brandy, cigars, chauffered cars and free trips on military jets.

Mr. Duscha seems blithely unaware—or deliberately neglects to mention—that the House cut some $2 billion from the defense budget last year and the Senate restored only $258 million of this and compromised on reducing that by $120 million in joint committee.

Mr. Duscha could not mention this, of course, because it kills his whole point. The fact is that the defense budget-cut was the largest since 1958.

THIS DOES NOT SQUARE AT ALL with the distorted picture Mr. Duscha is trying to peddle. He also eliminates other significant facts.

He points out that the Senate crushed, 74 to 2, an amendment by Sen. George McGovern (D-S.D.) to cut the defense appropriation by 5%. He says the Senate "then went on to pass the defense appropriations bill, which amounts to half the Federal budget, after spending a leisurely afternoon in desultory discussion of a few of its provisions. There was none of the probing and sharp questioning that marked the Senate's three-week debate later in the fall on the foreign-aid program . . ."

But the author neglects to mention that committees had been at work on the bill for many months and that an amendment proposed on the floor by Sen. Leverett Saltonstall (R-Mass.) calling for a general 1% cut in defense procurement was defeated by only one vote.

This inaccuracy and distortion continues throughout the article. Mr. Duscha tells us in his text that Mr. McNamara "has injected more genuine competitive bidding in the awarding of defense contracts" and we are then promised that next month's article will cover "the disturbing trend away from competitive bidding."

Harper's says these articles are "a carefully documented effort" to contribute to the understanding of the Eisenhower charge. We say that, judging from the first, they are inaccurate, biased hogwash.

William J. Coughlin

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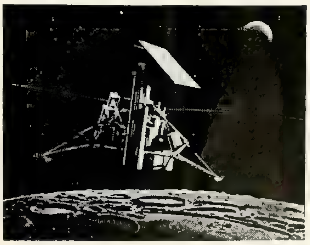

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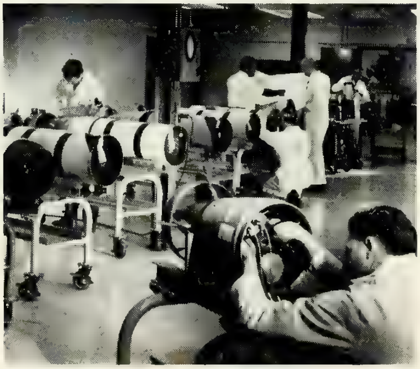

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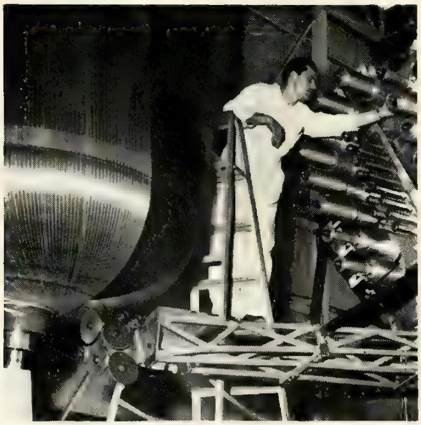

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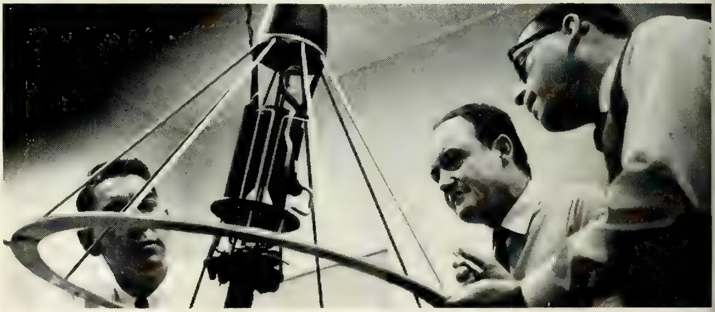

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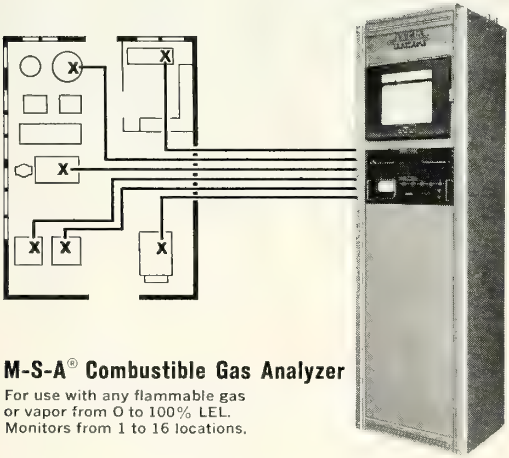

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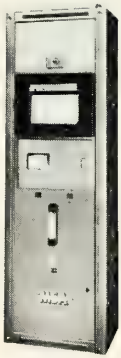

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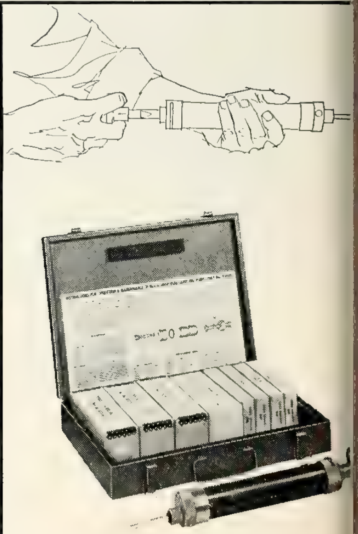

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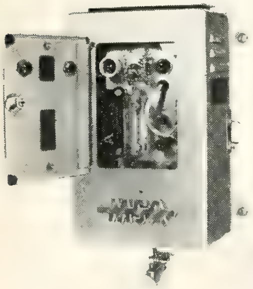

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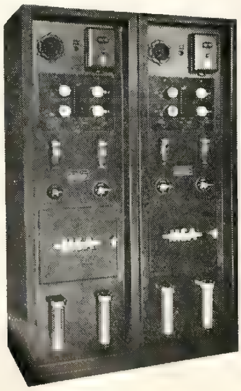

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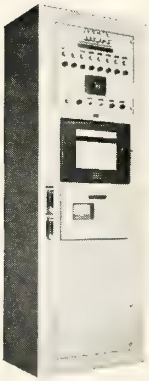

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Volume 14, Number 12 March 23, 1964

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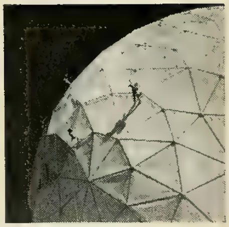
THE COVER



Painters at work on 150-ft.-dia., 134-ft.-high radome—believed to be largest metal-space-frame radome of its kind—housing AF/MIT Lincoln Labs/North American Aviation Haystack antenna, slated to be turned on in July. Radome was supplied by H. I. Thompson Fiber Glass Co. See p. 26.

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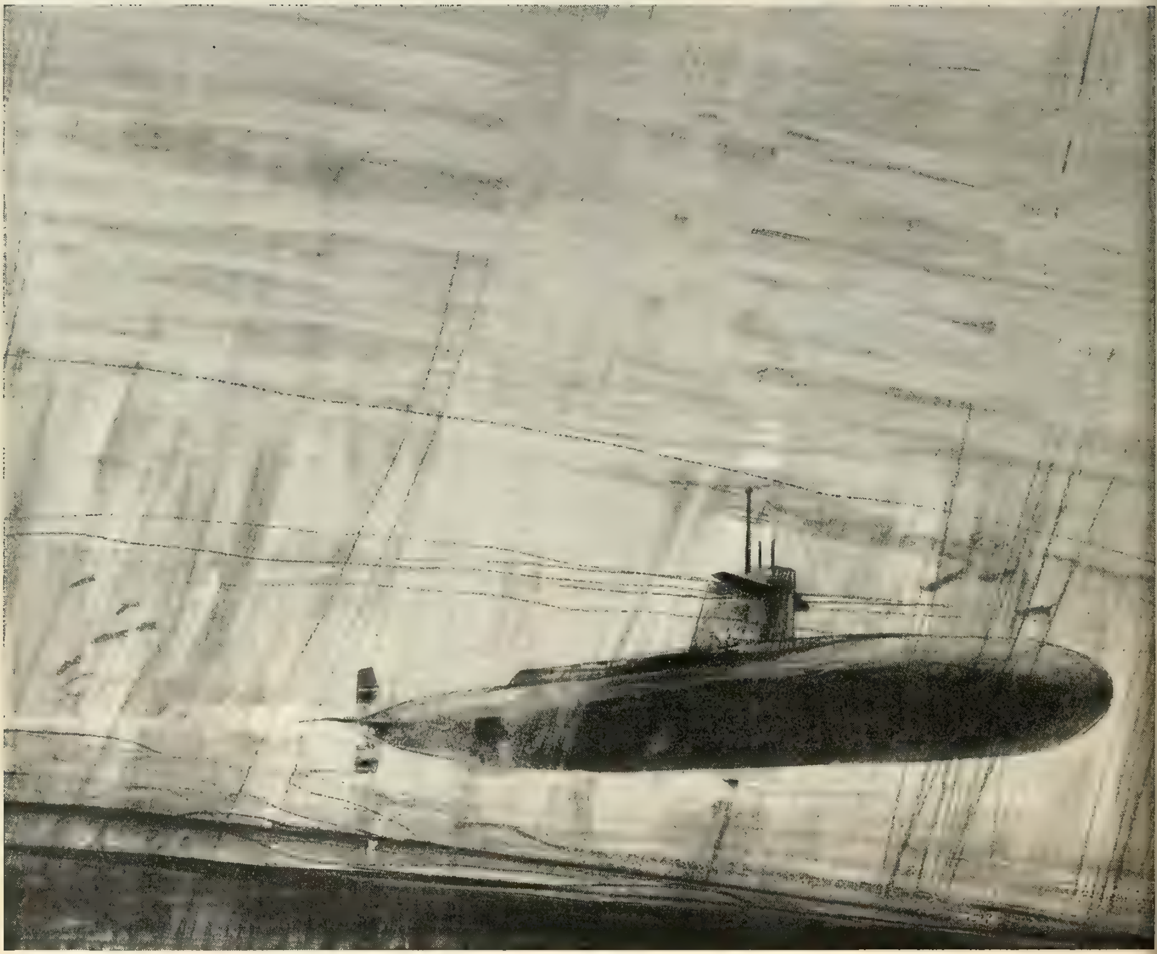
47,055 copies this issue

† U.S. Reg. Pdg.

Is this
what most engineers mean
when they say
RELIABILITY?



An integrated inertial navigation system
that can guide a nuclear-powered submarine for
weeks in the ocean depths without surfacing.

That is reliability. The system is called the Mark II SINS. It was designed, developed, and produced by the Autonetics Division of North American Aviation. Today it guides the Free World's nuclear-powered, Polaris-carrying submarines, accurately giving them their position and velocity plus the direction of north at all times. It is but one of many achievements pioneered by the engineers and scientists at Autonetics in the area of integrated systems application with built-in cost effectiveness. These achievements by Autonetics have now set a new standard of reliability for the entire electronics industry.

North American Aviation/Autonetics

letters

EM Compatibility

To the Editor:

After reading your Feb. 17 editorial ("That Boston Center"), it would appear that there may be some trends in electronics which are not being given enough consideration. One of these is now popularly being called electromagnetic compatibility and is regarded as the next big step in this field.

The study of electromagnetic compatibility should be centered where as many disciplines as possible are available and where broadly trained personnel can be sent to centers where their training can be used in basic systems design and not used to patch up the mistakes of others. These men cannot be specialists, but have to know the value of specialized information and where it is available.

It is true that each space center needs top capabilities in electronics and can probably develop these capabilities on its own. But when it comes to electromagnetic compatibility, a much broader umbrella is needed. New England, at least, is conscious of this broadening responsibility.

Rexford Daniels
President
Interference Consultants, Inc.
Boston

Dr. Saenger's Vision

To the Editor:

The Feb. 24 issue of M/R noted the untimely death of Dr. Eugen Saenger. You printed "probably his last words to the press," based on an interview last summer.

For the record, I interviewed Dr. Saenger in Berlin last October. I was preparing a magazine article about the growing European space effort. (Unfortunately, I was drafted before I could complete it.) Of all my sources, he was the most helpful. He discussed the situation at length and frankly, including the controversial issues that others had ducked.

He was optimistic about the future of space research. He predicted that public support for space research would grow, even in Europe, where it is much less even than in the United States. Dr. Saenger was also thinking far into the future. He was already planning manned trips throughout the solar system and common tourist travel to the Moon.

Dr. Saenger, still far ahead of his time, will be missed.

Michael B. Wall
Editor
The Army Flier
U.S. Army Aviation Center
Ft. Rucker, Ala.

Remote Moon Analysis

To the Editor:

In a recent issue of M/R was a brief report on Dr. von Braun's visit to Texas A&M, including mention that the visit may have "turned up a boon" for the Moon project in the form of the "discovery" of a "device" that may permit remote neutron activation analysis of lunar soil.

The device described as a "five-inch atom smasher" is fully described by its original inventors in the March, 1960, issue of the *Review of Scientific Instruments* under the title, "The Development of a Compact Evacuated Neutron Source."

The possibility of remote neutron activation analysis of the lunar crust is fully explored and documented in a report issued by the University of California, Lawrence Radiation Laboratory, entitled "Remote Analysis of Surfaces by Neutron Gamma Inelastic Scattering Technique," *UCRL Report 6327* by C. D. Schrader and R. J. Stinner.

If Dr. von Braun is seriously thinking of putting taxpayer dollars into such a scheme, I would suggest he talk to those who did the original work on both the device and the idea, for the writer has personal knowledge that such a package was being designed as long ago as 1961, at Livermore, Calif. Who knows, perhaps he can save a few dollars and avoid a lot of unneeded reinvention of wheels.

Herbert S. Dunkerley
Schenectady, N. Y.

Space/Defense Bluffing?

To the Editor:

It's becoming increasingly clear that our space and defense efforts are being looked upon by many people as a sort of poker game, in which you try to collect the biggest winnings, even if you have to bluff it. The question arises, whom are we bluffing? Let me illustrate:

Bluff No. 1: We are training capable people of technical background in government-sponsored carrier-building programs, to head space and defense management groups.

Truth: We are giving, at government expense, watered-down college courses to longtime civil-service employees, who by hook and crook have eliminated every technically competent person from the program.

Bluff No. 2: Industry is carefully supervised by highly trained specialists, who appoint patriotic, highly trained people to monitor product standards set by the armed forces or space scientists.

Truth: Every person who tries to really improve quality is summarily fired, blacklisted or forced to resign . . .

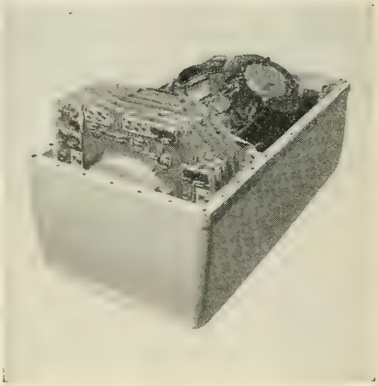
Bluff No. 3: We are reducing spending without endangering quality of either defense or space programs.

Truth: Saving $1 by hounding and threatening engineers with layoffs and suspensions, we write contracts with labor unions that cost $2 to prevent them from delaying essential work by strikes that are even more costly.

I believe that our stature as a world power is increasingly questioned . . . Our bluffs are being called.

Henry Albert
Los Angeles

And is this what most engineers mean when they say APPLIED MICROELECTRONICS?



It is called the N16 Autonavigator.

The lightweight N16 Autonavigator is another major achievement in inertial navigation by the Autonetics Division of North American Aviation. Drawing on years of experience and extensive research, Autonetics engineers have applied microelectronics to navigation systems.

N16 is more than a single autonavigator. It's a whole family based on proven concepts, utilizing standardized equipment and featuring modular construction for growth potential. The basic N16 is designed specifically for high performance tactical and transport aircraft. The N16S adds capabilities required in space. The N16M accommodates the same common sub-systems to the needs of ships and submarines.

This N16 series utilizes precision gyros and velocity meters which are scaled-down versions of inertial components now used in major weapon systems. Use of microcircuitry, integrated circuits and other recently-proven techniques provides high accuracy plus a reliability 10 to 30 times that of conventional guidance systems.

The basic N16 total system weight is 40 pounds; volume, 1.0 cubic foot; and the total power consumption is only 140 watts, including the computer with its built-in self-check and calibration features.

A low total life cost is assured by the high reliability, simple operator requirements and engineered ease of maintainability.

This is but one more example of how the engineers and scientists at Autonetics are forging ahead in the field of applied microelectronics and total systems integration... another reason why Autonetics today is continuing to set standards for the entire electronics industry.

**North American Aviation
Autonetics**

H
HONEYWELL

INSTRUMENTATION NEWS

MILITARY EDITION

Number 2-MI

Honeywell Designs Custom Cryostats

POTTSTOWN, Pa. — Cryostats designed by Honeywell's Special Systems Division for the calibration of platinum and germanium cryogenic temperature sensors are now in service at NASA's Huntsville, Ala., facilities in connection with the Saturn space vehicle program.

The self-contained, integrated systems include dewars, precision control equipment, high-accuracy measuring circuits and digital readout equipment. Also in the relay rack-mounted systems are programmers for automatic operation and NBS calibration reference standards.

Calibration is accomplished by inserting test and control sensors and the primary standard into the appropriate cryogen — liquid helium, nitrogen, hydrogen, etc. By controlling the temperature of the cryogen at various levels, defined precisely by the primary standard, calibration data is developed and printed out. Up to six sensors of the same type can be calibrated at one time.

All Honeywell cryostats are custom-designed. Inquiries should include such information as calibration range, sensor type, sensor size, number to be calibrated at one time, accuracy requirements, and typical calibration curves.

WRITE FOR FULL INFORMATION

New Portable Lab Recorder Measures 100μv to 100v

PHILADELPHIA—Honeywell's Philadelphia Division recently introduced an all new portable lab recorder capable of measuring voltages from 100 microvolts full scale to 100 volts dc full scale without auxiliary equipment.

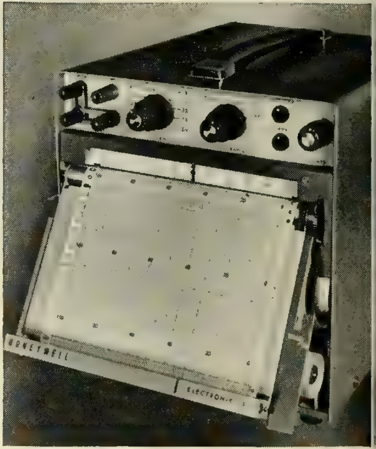
This new instrument, the *ElectroniK 19* strip chart recorder, combines a wide measuring range with a variety of features which its designers say makes it one of the most versatile recorders available for laboratory or test applications.

In introducing the new instrument, Honeywell Market Manager William Forsyth emphasized that the *ElectroniK 19* recorder has been designed specifically to meet the needs of the military test market.

"For example," he explained, "the wide selection range of the new instrument makes it possible to measure with one recorder signals which usually require several units or auxiliaries such as preamplifiers or attenuators."

The *ElectroniK 19* lab recorder has a unique tilting platen that pulls up from a vertical position and locks at either a 30° or 45° angle.

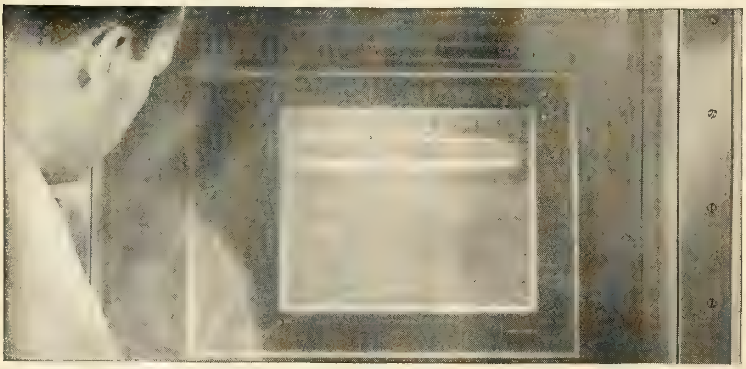
"There also is a tear-off bar for fast, easy removal of selected records," Forsyth pointed out. "When you add the completely removable chart transport and quick thumb-wheel selection of 10 chart speeds from one inch in 10 minutes to an inch a second, you can appreciate how we have engineered this instrument for the user."



ELECTRONIK 19 **PORTABLE LAB RECORDER has a range from 100 microvolts to 100 volts full-scale, weighs less than 20 pounds, occupies less than one square foot.**

Forsyth also noted that the new recorder's potentiometric measuring circuit provides ±0.25 per cent full-scale accuracy and up to 100 per cent of full-scale zero displacement to expand the effective range when the signal goes off scale. Other standard features include high-performance, null-balance servo with frequency response down less than 1% full scale at 5 cps from 10% peak-to-peak amplitude, along with wide measuring capacity from low-impedance detectors to high-impedance bridges.

WRITE FOR FULL INFORMATION



NEW *ELECTRONIK 16* Strip Chart Potentiometer is subjected to temperature and humidity extremes in a Honeywell evaluation laboratory environmental chamber. An intensive evaluation program for the *ElectroniK 16* line assures quality, overall reliability and repeatable performance capability under a wide range of operating conditions.

Honeywell

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PHILADELPHIA, PA. 19144

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The Countdown

WASHINGTON

RAM Launching Looms

NASA plans to launch this week a 210-lb. scientific experiment to study the problem of radio blackout when a spacecraft re-enters the Earth's atmosphere. Ballistic launch of the experiment—Radio Attenuation Measurement (RAM)—is set for March 26.

260-in. Half-length Eyed for Saturn

Possibility of using the half-length 260-in. solid motor with the S-IVB stage of *Saturn IB* is under consideration at the space agency. This would make it feasible to put 50,000 lbs. in near-Earth orbit, compared with 32,000 lbs. in the presently planned booster. The projected combination might also offer advantages of simplicity.

Pentagon Prepares to Borrow Syncom

Dept. of Defense plans some operational communication experiments with NASA's *Syncom* satellite. DOD will use the system to send live traffic between Manila and the U.S., as well as for training ground crews. Some delayed television transmission between Japan and either Hawaii or California is also envisioned.

Japan-U.S. TV Premiere at Hand

First "live" TV transmission from Japan to the United States will take place March 25. The eight-minute show will be flashed between 7:32 and 7:40 a.m. EST via the *Relay II* communications satellite.

Lunar Static Electricity Feared

One of the nightmares NASA scientists are having about the Moon involves the possibility that if there is a deep layer of surface dust, static electricity might turn a landing object into a dust-catcher. Spacecraft seals might be permeated, astronauts blinded, and a lunar mission effectively wrecked.

Mars Biological Probe in 1966 Out of Picture

Prospect of landing a biological probe on Mars during the 1966 *Mariner* mission is now ruled out, NASA officials say. A decision is imminent on whether a lander of the size that could be accommodated on this mission would offer any real advantages over a highly instrumented flyby.

Army Pushes for Missile Simplification

U.S. Army Missile Command is reported getting promisng results in its research into ways missiles can conrolled by short, powerful bursts of pressurized gas. Army scientists view the project as of major importance in efforts o place a premium on simplicity.

Fulbright Hones Space Budget Knife

Look for a move from the Senate floor to cut the NASA budget by about $500 million. Last year a similar amendment offered by Sen. J. William Fullbright (D-Ark.) was defeated by only a half-dozen votes. The Senator has already been asking NASA officials what certain cuts would do to the space program.

Astronaut Academy Proposal Weighed

The House Space Committee is considering a bill introduced by Chairman Olin Teague (D-Tex.) of the manned spaceflight subcommittee to create a single academy for all U.S. astronauts. The institution, which would be run by NASA, would cover any person intended to participate in flight reaching "an altitude of more than 50 miles above the surface of the Earth."

INDUSTRY

Autonetics Upgrades Polaris Sub Navigation

Inertial navigation systems for the first-five George Washington-class *Polaris* submarines are being modified and improved by North American Aviation's Autonetics Div. Changes will permit the subs to launch all three classes of *Polaris* missiles. Currently, they can launch only the *A-1* version.

NASA, DOD Pooling Problem Records

NASA and the Dept. of Defense are about to embark on another joint program which may have wide repercussions in industry. Both agencies will set up a system to record just what technical problems cropped up during development of various space systems. Pooling of data will be at the "black box" level and may go even lower at a later date. The information will be available to engineers working on other projects.

New Development in Transducers

A new low-modulus d-c semiconductor instrument has been developed by Gulton Industries. The transducer simultaneously measures normal shear and strain, Gulton reports, and has been used by solid-propellant makers to determine case bond shear strains in inert loaded rocket motors which have been subjected to axial and transverse accelerations up to approximately 50 g's. The firm says results have shown excellent correlation with theoretical analysis of simple propellant grain designs.

Apollo Communications Bids Studied

NASA expects to select a contractor for the unified S-band communications system for Project *Apollo* by May 15. Some 14 firms have submitted bids to Goddard Space Flight Center, and almost all are team efforts involving more than one company.

INTERNATIONAL

French Near Testing of New Booster

France is reported ready to test within a few weeks a solid-propellant booster delivering 56,000 lbs. of thrust. Also continuing is development of the *Regent*, a still-secret successor to the *Diamant*, with a payload of one to two tons in Earth orbit.

Navy Seeks ASMS Proposals

The Navy has invited 11 firms to submit proposals for the Advanced Surface Missile System (ASMS), which would in the 1970's replace the current *Talos, Terrier* and *Tartar* family of shipboard missiles.

The move is seen as a step toward standardization of the Navy's shipboard missiles and the development of a system that will eventually overcome the difficulties experienced in the cancelled *Typhon* design.

The proposals will cover radar gear and launchers, as well as the missile itself.

Firms receiving the Navy invitation were Boeing, General Electric, Hughes, ITT, Philco, Raytheon, Sperry Rand, Sylvania, RCA, Westinghouse and North American.

Low Pressure Rocket Developed

A series of lightweight space propulsion components are emerging from a development program conducted by the Martin Co. into an ultra low pressure rocket system for the Air Force. The components include a bellows-driven fuel accumulator for zero-g restarts, low leakage valves and extremely thin aluminum storable propellant tanks. The bellows respond to positive pressure from stored helium in the restart operation. The Air Force acceptance tests were run at Martin-Denver's Cold Flow Labs.

U.S.-Japan Studies Proposed

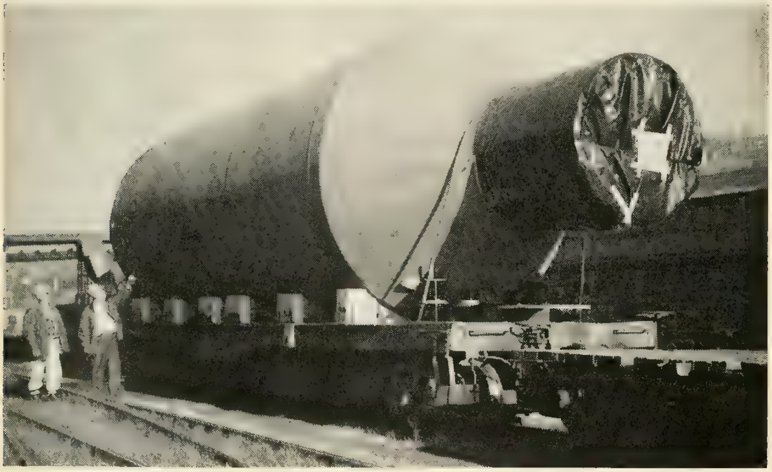
A small group of U.S. and Japanese meteorologists have worked up informal recommendations that may lead to increased international cooperation in understanding and controlling hurricanes and typhoons.

Satellites and rockets are expected to play a key part in the effort, which is part of the recently established Japan-U.S. Science Cooperation Program. Although the recommendations that came out of the week-long conference that ended Friday in Miami were not officially formulated, they did deal with the problems of interpreting hurricane data sent from satellites, predicting the onsets of hurricanes and typhoons and modifying the weather related to massive cyclonic storms. The conference was sponsored by the U.S. Weather Bureau and the University of Miami.

"We're concerned particularly with infrared radiation from hurricane cloud systems and tropical perturbation systems," Robert H. Simpson, Asst. Director of Research, U.S. Weather Bureau, told MISSILES AND ROCKETS. But this is only one phase of the problem. "We're concerned about the data problems, use of aircraft, weather modification and amelioration of hurricanes."

Simpson also pointed up some of the scientific roadblocks that a cooperative effort might help clear away: how do you interpret cloud tops from satellite photographs or derive the heights of clouds? How do you put absolute numbers on infrared radiations and tell what they mean in terms of the energetics of clouds?

Greatest stress in the work between the two countries will be on exchanging scientists for a better understanding of each country's meteorological operations. The National Science Foundation has been designated the executive agency for administering the U.S. part of the program and the Japanese Research Council, for the Japanese part.



Antenna Shaft Heads for Green Bank, W. Va.

SHAFT WEIGHING nearly 200 tons leaves East Pittsburgh, Pa., plant of Westinghouse Electric Corp. on its way to Green Bank, W. Va., for use at the National Radio Astronomy Observatory. Narrow end of shaft (foreground) will revolve in a steady bearing. Far end will support yoke and 140-ft.-dia. reflecting dish. Associated Universities, Inc., N. Y., operates the observatory under contract with the National Science Foundation. Stone and Webster Engineering Corp., Boston, is in charge of the engineering portion of the project.

Hughes Gets ComSat Award

The contract awarded Hughes Aircraft Co. by the Communications Satellite Corp. last week is expected to top $8 million and will cover development, fabrication, assembly, test, maintenance and service for the *"Early Bird"* proposed experimental operational communications satellite system.

The incentive-type contract has been signed by Hughes, but not by ComSat officers. It rests at the Federal Communications Commission offices in Washington for a statutory filing period prerequisite to the corporation's binding signatures. Basis for the new satellite (of which there are initially to be three) is the *Syncom II* synchronous comsat developed by Hughes.

Redstone Gets New Lab

The Army Missile Command's Research and Development Directorate is consolidating activities in a $4.4-million laboratory facility at Redstone Arsenal, but the move has not been dictated by new missile programs.

A three-story building, which contains 205,000 sq. ft. of floor space, was dedicated March 12 and named the Francis J. McMorrow Missile Laboratories to honor a former AMC commander.

Moving immediately into the facility will be major portions of the Structures and Mechanics, Ground Support Equipment, Electromagnetic and Advanced Systems Laboratories. Following within a few months will be the Army Inertial Guidance and Control Laboratory, which will occupy a $2-million addition to the present structure.

Col. Daniel F. Shepherd, head of the Directorate, stressed that construction of the new laboratories building was the result of rapid growth and the need for a centralized facility rather than new programs or a cutback in work by contractors.

He said the need for a central laboratory facility appeared at the time the Von Braun team moved from the Army to NASA and took along facilities worth about $100 million.

Bleymaier New MOL Chief

Brig. Gen. Joseph S. Bleymaier, *Titan III* development deputy, has been named to the new post of Deputy Commander for Manned Systems in the Space Systems Div. of Air Force Systems Command.

The new position puts Bleymaier in the dual role of directing the overall field-level program for all aspects of the *Manned Orbiting Laboratory* program and serving as the deputy commander, SSD.

Williams Joins Aerospace

Aerospace Corp. has confirmed the appointment of Dr. Walter C. Williams, former deputy associate administrator for NASA manned spaceflight operations, as general manager of the firm's Manned Systems Div. (M/R, Mar. 16, p. 7).

Williams, also elected a corporate vice president, will begin work with Aerospace Corp. next month. At NASA, he held a key management role in Projects *Mercury, Gemini* and *Apollo*.

Space Simulator Claims Victim

An accident at California Institute of Technology's Jet Propulsion Laboratory resulted in what is believed to be the first fatality in the U.S. space program.

JPL technician Ralph A. Lowe died from injuries suffered last week when a dry nitrogen line exploded in the space simulator he was in.

Shots of the Week

Unsuperstitious rocketeers conducted four shots on Mar. 13, three of them successful.

- From Cape Kennedy, the Air Force fired a *Minuteman* and a *Blue Scout*. The *Minuteman* carried an advanced nose cone test, and its firing was termed a success. The *Blue Scout* failed in an effort at a 23,000-mi. probe to study the Earth's magnetic field after its fourth stage failed to ignite.
- NASA's *X-15* rocket plane underwent its 102nd flight on the 13th with a microphone embedded in its airframe to record the noise of air turbulence over its surface. The test was designed to help predict metal fatigue in supersonic transports. Flown from Edwards AFB, Calif., by NASA pilot John McKay, the craft reached a speed of 2,850 mph and an altitude of 71,000 ft.

The Air Force, also on the 13th, successfully launched a *Titan II* missile from a silo at Vandenberg AFB, Calif.

- On Mar. 18, the Soviet Union launched *Cosmos 26*, an unmanned satellite, carrying scientific instruments. Indications are that the satellite was functioning normally. Period was reported as 91 min.; inclination, 49 degrees; apogee, 403 km; perigee, 27 km.
- A *Nike-Cajun* was fired from the Air Force's Fort Churchill, Manitoba, launch site Mar. 18 carrying instruments to relay information on the Northern Lights to Rice University scientists on the ground.

Budget Clears Committee

The last of the three House Science and Astronautics subcommittees completed its presentation on the NASA Fiscal Year 1965 budget request to the full committee last week with action pretty much following that predicted (M/R, Mar. 16, p. 12).

The Advanced Research and Technology subcommittee, chaired by Rep. Ken Hechler (D-W.Va.) voted additional cuts of $29.9 million, which were supported by the full committee (see p. 11).

However, a proposal to cut $12,061,000 from construction and administration funds for the Boston Electronics Center, which drew a split vote in the subcommittee, was overturned in the full committee. The full committee also made additions of $3 million for high-energy liquid propellant work and $1 million for advanced solid work.

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By end of April . . .

DOD-ComSat Decision Sought

Military use of commercial satellites hinges on adequate security; military-operated systems remain possibility

by James Trainor

DEGREE OF vulnerability to enemy jamming is the major roadblock to an agreement between the Dept. of Defense and the Communications Satellite Corp. for military use of the commercial system. This "absolutely key government requirement" could conceivably preclude any agreement.

Negotiations between the DOD and Comsat Corp. have been going on since November. They are expected to lead to an agreement—or to the realization that no agreement is possible—sometime between April 15 and 30. "At that time," Dr. Eugene Fubini, Deputy Director of Defense Research and Engineering, told a Congressional subcommittee, "we will either agree to agree, or agree to disagree."

Meanwhile, DOD is continuing a Philco/STL study of a military system at a sustaining level of $400,000 per month. Additional costs, such as in-house and contractual systems engineering, run the monthly costs to $600,000. If the negotiations with Comsat Corp. fail, this team would be awarded a contract to develop the military comsat system at a cost of $50-60 million.

• **DOD anti-jamming needs**—In setting the specifications for a military system before the civilian corporation, DOD made it clear that a *sine qua non* for its participation in a civilian system was the same assurance against electronic jamming as it would have if DOD developed the system. Although the Comsat Corp. has provided some degree of anti-jamming capability, Defense officials do not feel that it is sufficient.

Any satellite can be jammed, Fubini pointed out to the Military Operations subcommittee of the House Committee on Government Operations, but the idea is to force the enemy to pay the highest possible—and perhaps a prohibitive—price to jam the system. The proposals of Comsat Corp. do not even approach extracting such a price, he asserted.

"If DOD has its way" on this point, Fubini stressed, "an agreement can be signed tonight."

• **Whither military system?**—The hearings were convened to determine why DOD had gone into negotiations with Comsat Corp. for use of its system when, since 1958, there had been a clear identifiable military requirement for a communications satellite system. In fact, when Dr. Fubini appeared before the same committee in July, 1963, he had reasserted this requirement and its urgency.

The shift, it appears, came in late September after a source selection board had briefed DDR&E on the results of the program definition phase and made its recommendation to select the Philco/STL team over the General Electric/Motorola entry. At about the same time, Secretary of Defense Robert S. McNamara asked DDR&E to review the requirements for a military system and determine if they were still valid.

As a result of this review, Secretary McNamara, in a letter dated October 11, 1963, requested that Comsat Corp. express any interest it might have in providing communications services to DOD and the means by which it believed it could do so. Dr. Fubini candidly admitted that he had not thought the corporation would be interested and was therefore surprised when it replied expressing interest.

Factors that made DOD change its mind about developing its own system included the realization that ownership of the spaceborne portion of the system was not as essential as ground station ownership—a factor that had not been given sufficient weight before—and the previously "incredible" idea that one system could meet both the military requirements for a few channels and civilian needs for many channels. Finally, the government policy of buying from the civilian sector wherever possible was a factor.

The military system would have involved 60 medium-altitude satellites in random orbits, with six to eight satellites launched by a single booster. The upper frequency limit would have been 8,000 mc. and the lower, 7,000 mc. The satellites would have been simple, light basketball shapes with relatively low power.

• **Advantages of one system**—If agreement with Comsat is reached, several important advantages will accrue as the result of using a single system. First and foremost would be the savings, which would amount to the order of magnitude of annual operating costs. These, Fubini estimated at $40 million dollars, while at the same time he said that $25-30 million would be a reasonable share for DOD participation in a worldwide communications system.

Also listed were important capabilities to be gained from use of the Comsat Corp. system, which would operate at the optimum frequency of 4,000 mc. and would provide six times the channel capacity. Antennas could also be made six times smaller.

"This is one case where everybody gains," Fubini noted. One system of 29 satellites would have the same capability as two systems of 24 satellites. By having multiple users, one system can provide the same capability with 30% fewer satellites with two to four times the power.

Finally, if both requirements can be filled by one system, Fubini said, the idea behind the Comsat Act would have been proven beyond the wildest dreams. This could have further consequences that can't be foreseen.

Despite the advantages offered by the Comsat system, DOD in waiting for it would be losing 10-12 months—since the initial launch of a Comsat satellite is not planned until early 1966, with an operational capability in mid-1967. ■

In Senate testimony . . .

NASA Launches Fight to Restore House Fund Cuts

Mueller leads string of officials warning that slashes will set back both manned and unmanned program planning

by Heather M. David

A STIFF BATTLE is being waged by NASA for restoration of funds cut by the House Science and Astronautics Committee from its Fiscal Year 1965 budget request.

Space agency witnesses told the Senate Aeronautics and Space Sciences Committee, now considering the bill, that they must have almost all of the $110 million cut from their programs. The House bill would provide only $5,193,810,500.

- **Manned spaceflight**—Dr. George E. Mueller, associate administrator for manned spaceflight, testified that NASA had increased its advanced missions fund by $3.9 million (all of which was cut by the House) over last year's funds in order to go into program definition studies in selected areas "to permit a more detailed specification of work that needs to be performed." Last year's work, he said, was of a broader nature.

Mueller attacked the 10% cut imposed by the House on all manned spaceflight construction costs, claiming that NASA has projected costs on experience and sound specifications. "We believe that if the cut is sustained, we will in fact not be able to procure the facilities that we need and that the House subcommittee agrees we need."

Addressing himself to the 5% cut in a $304.6-million fund for administrative operations, Mueller said NASA would not be able to purchase as much of the computer equipment as seemed desirable from the standpoint of the long-range economy of the government.

- **Space Sciences**—Associate Administrator Dr. Homer Newell made a strong plea for the large orbiting observatories, all of which were cut in some part by the House.

A $2.5-million cut in *Orbiting Solar Observatory (OSO)* funds would, he said, directly affect work on a spacecraft planned for continued work during the International Quiet Sun Year and during the subsequent buildup of activity in the approaching maximum flare period. The spacecraft is under contract already, Newell said, and "we would have to do some back-pedalling."

The three last *Orbiting Geophysical Observatories (OGO)*, which the House committee suggested should be dropped to save $6.5 million, might have been victims of some misunderstanding in the House, he said. While the House suggested that NASA stretch out its launch schedule from two to one launch a year, Newell pointed out that NASA was not planning to launch two identical spacecraft each year as the House assumed. One craft would be placed in eccentric orbit to travel to the edge of the magnetosphere; the other would be in polar orbit in the near-Earth region. Thus, if only one were launched a year, each mission would be accomplished only once every two years.

Newell also told the committee that the Russians "launched more satellites in this field than we did."

He said the problem with *Orbiting Astronomical Observatory (OAO)* (cut $7 million by the House) was that the complexity of experiments required long lead times in the experiments, which are the pacing items. Funding now would permit NASA to get under way with the scientific community well enough in advance to be "sure we are ready," he said.

Surveyors 8 and *9*, which the House suggested be deleted at $12 million, will leave NASA with less than the minimum requirement of spacecraft to accomplish the task of providing lunar surface information in advance of *Apollo*, the space sciences chief said. "We cannot feel assured that every one will work," he said.

While the House cut $1.2 million from a fund to conduct economic studies for the use of communications satellites, on the basis that NASA shouldn't be doing this kind of work, Newell indicated that NASA still feels it should conduct a few studies to be aware of the problems.

A $147,000 cut in advanced design funds can be lived with, Newell said.

- **Advanced Research and Technology**—Dr. Raymond L. Bisplinghoff asked for restoration of all cuts to his division.

A $1-million cut in the M-1 engine will really hurt the program, he indicated. "We are operating it at a minimum level now," he said, "and we do not like to see it cut any further."

Bisplinghoff indicated general approval of the House's actions in adding $3 million for high-energy liquid research, and $1 million for advanced solid rocket work. (See p. 12.)

But he objected to the House's suggestion that $1.5 million of the nuclear rocket fund (also cut by $1 million) be added to a portion set aside for gaseous-core fission reactors. He pointed out that $1 million already was apportioned for this research, and said he felt that $2.5 million would be a proportionately heavy slice from a $58-million total nuclear category.

A number of additional cuts in advanced research and technology (space vehicle systems, $1.8 million; electronic systems, $1.4 million; nuclear electric systems, $1 million; space power, $500,000; and human factors, $700,000) drew from Bisplinghoff the general comment that these areas are already operating at a lower level than last year. He noted that OART'S budget is about the same even though it has taken on the large solid work and M-1.

- **Tracking and data acquisition**—A $7-million cut in operations for the three tracking networks was scored by Tracking and Data Acquisition Director Edmond C. Buckley. He said the costs were based on several years of operating, and he felt they were sound.

Buckley said that the $5 million the House slashed from equipment and computer operation was in the same category—these items have been procured before and NASA knows the price.

While the House refused a $1.67-million fund for construction of a new *Apollo* station on the basis that it could be deferred for one year, Buckley said that this station must be operational in 1966, and that it will take about two- to two-and-a-half years to construct and integrate it. ■

Congress Prods NASA's Propulsion Development

A MOVE to speed up NASA's effort in advanced propulsion systems is gathering force on both sides of Capitol Hill.

Rep. Olin Teague D-Tex.), chairman of the NASA Legislative Oversight Subcommittee of the House Space Committee, called a special session "to emphasize our interest in seeing that there is progress in this area."

Concern over the present rate of progress in propulsion systems has marked all of the subcommittee's hearings this year. This year, the full committee voted to add $3 million for work on high-energy liquid fuels, and $1 million for advanced solids, beyond the amounts which NASA had requested.

Last year, NASA received a gratuitous $2 million for high-energy propulsion work, about half of which was spent on diborane research. The $4 million extra this year marked the largest amount added since the first year, when $10 million more than requested was given NASA for propulsion research. Said one congressman: "We are in the strange position of trying to force a research and development agency to do more research. They have too often been taking R&D money for facilities."

Rep. James G. Fulton (R-Pa.) suggested that NASA take over a diborane plant owned by the Air Force at Muskogee, Ala., reported to be worth $38 million. This is being kept on "hot standby," but is not being used, he indicated. He suggested that the extra $3 million would enable NASA to make use of this plant to produce large amounts of fuel for testing at rocket plants.

"We must move beyond 1942 fuels," Fulton said.

• **No limits**—Dr. Theodore B. Taylor, chief of the High-Energy Fluid Dynamics Department at General Dynamics, told the open session that researchers see "no limiting physical influence" to attaining specific impulses up to 100,000 seconds, although committee members conceded that this was far in the future.

Congressmen expressed concern about the future of the *Orion* project (for which General Dynamics is prime contractor), which the Air Force seems to be losing interest in funding. NASA has thus far shown willingness to invest only about $100,000 a year in *Orion.*

George H. McLafferty of United Aircraft described developments in gaseous-core nuclear rockets, which he said must be regarded as "somewhat speculative" because of the problems that must be overcome. However, he said, "analyses indicate the possibility of values of specific impulse between 1,500 and 3,000 sec., and values of thrust to weight ratio considerably greater than unity."

He urged support on solid-core nuclear rockets and high-pressure chemical rockets "to fulfill intermediate requirements," and to development technology for the former.

A plea for *NERVA* was entered by both Aerojet-General's William C. House and Westinghouse's Woodrow E. Johnson. Both pointed to the progress of the program, and House told the committee that "we sincerely urge that you encourage NASA to work with undivided attention to complete the feasibility work and be prepared to assist in relaxing the constraints with regard to vehicle and facility programs so that our space effort may capitalize on this imminent breakthrough."

• **Senate side**—The Senate also has been probing into NASA's propulsion program, and some House members said that there might be a move to get a full-scale investigation in the Senate.

During hearings last week, Sen. Richard B. Russell (D-Ga.), chairman of the Senate Armed Services Committee and Defense Appropriations subcommittee, sent a message saying that he saw a "low pace" in the large solid program, and indicating that NASA should think now about starting the next phase and funding for it as well. Russell is credited with seeing that the large solid program was continued in spite of DOD disinterest.

The Senate committee voiced fear that SNAP 8 might end up in the same situation as SNAP 10A, with no mission assigned to it and thus losing its flight program. NASA witnesses held that "we don't think we should go to a flight program until the mission comes into view." ■

Probe Leads to Sharper AF Procurement

THE AIR FORCE has made a number of changes in procurement procedures as a result of an investigation by a House Armed Services group.

The Special Investigations subcommittee, chaired by Rep. Porter Hardy, Jr. (D-Va.), released a report detailing a case in which "the chief of a relatively minor scientific branch in the Air Force Cambridge Laboratories, starting with a $44,000 contract with a small research firm of his choice, expanded it into one of more than a million dollars that may reach $10 million before the work is completed, and how he avoided the regulations that impeded him and invoked those he found useful."

The contract was awarded to Tyco Corp., of Waltham, Mass.

These changes have been made, according to a letter from Air Force Secretary Eugene Zuckert:

—Evaluation procedures have been revised to provide a better system of checks and balances.

—Territorial limitations will hereinafter be considered an exception to normal policy and will be reviewed by the division commander.

—Requests for quotations in the future will include a clear definition of the availability of Government-furnished property.

—Regulations for control and handling of unsolicited proposals will be closely adhered to.

—Increased emphasis will be placed on procedures authorizing the assistance of scientifically qualified individuals in the preparation of timely facilities capability reports.

Bids by April 20 . . .

Proposals Requested for First Study of Lunar Base Systems

NASA HAS REQUESTED proposals on the first of about 10 study contracts of lunar base systems which will be awarded before the end of Fiscal Year 1964.

The first contract calls for a feasibility and design study of possible payloads for the *Apollo* Logistic Support System (ALSS).

The system—utilizing the LEM truck spacecraft—probably will be the next major new development effort in NASA's manned spaceflight program. Some funding is expected to be available in FY '65 for preliminary engineering. Large hardware funding is likely in FY '66.

Twenty-eight firms have been asked to submit bids by April 20. A single contractor will be selected for the study—which the space agency says will be a sizable one—in mid-May.

At the same time, a NASA spokesman said the space agency is preparing to award a number of other contracts for studies of additional extended lunar exploration and lunar-base concepts.

These will include the Stay Time Extension Module (STEM), which would permit astronauts to stay on the lunar surface for periods up to two weeks, and the Lunar Exploration System for Apollo (LESA), a flexible system which could eventually grow into a lunar base.

Other areas which will be investigated in the studies include communication requirements, life support systems and the scientific need for such systems.

- **ALSS payloads**—The ALSS system would have an estimated development cost of $500 million. It would use the so-called LEM truck vehicle—the *Apollo* spacecraft's Lunar Excursion Module minus its ascent propulsion stage.

In the ALSS concept, a *Saturn V* launch vehicle would launch into an Earth-Moon trajectory a manned *Apollo* Command Module, a Service Module and the modified LEM truck for unmanned delivery of equipment from lunar orbit to the lunar surface.

Payloads for lunar surface operations would be stowed on the LEM truck. Following the ALSS landing, astronauts would arrive in the same area in an unmodified *Apollo* LEM to utilize the ALSS payloads in an exploration mission.

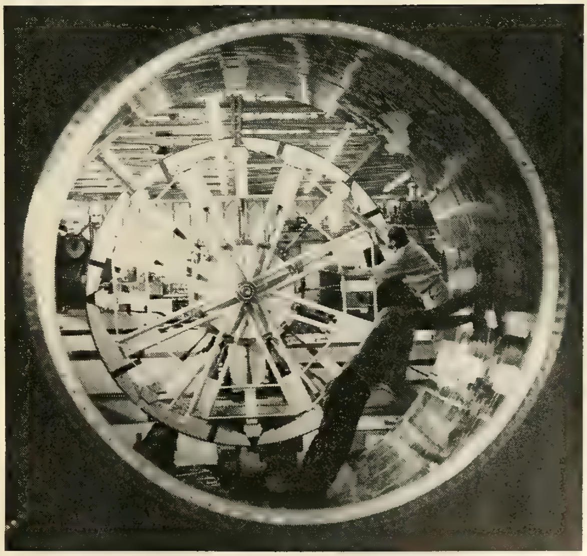
One payload to be studied is a lunar surface vehicle or mobile laboratory capable of supporting and transporting two *Apollo* astronauts for approximately 14 days. If surface conditions match expectations, such a vehicle should have a range of several hundred miles.

A second payload would include both a stationary shelter and a smaller vehicle of limited range.

Either the lunar surface vehicle or the shelter-and-vehicle payload would weigh about 7,000 lbs., including scientific equipment. The payload would be allowed to have a volume of about 2,000 cu. ft.

Preliminary design study is to include surface mobility concepts, environmental control systems, life support systems, lunar surface structures, power supplies, thermal radiators, human factors considerations, communication equipment and effects of the lunar environment on equipment.

The nine-month study will be managed by Marshall Space Flight Center, Huntsville, Ala. ■



Fastidious Treatment for Atlas Booster

INTERIOR OF ATLAS launch vehicle is carefully cleaned by hand at Astronautics division of General Dynamics, San Diego, to ensure against contamination which might cause defective welds. Big spoked wheel in background is specially designed welder which fits inside tank to hold weld sections.

Vance names committee . . .

DOD Acts to Standardize Data Flow

A TOP-LEVEL Dept. of Defense Council on Technical Data and Standardization Policy has been established to coordinate and provide guidance for standardization of the DOD technical information program costing more than $2 billion annually.

"It has become apparent that much greater progress is essential in this area," Deputy Secretary of Defense Cyrus R. Vance said in establishing the council, "in order to assure: 1) that we develop or acquire only that data which is needed to support well-defined . . . requirements; 2) that we acquire such data in the most economic, usable form and 3) that we devise automated retrieval and dissemination techniques which will make readily available to DOD agencies . . . all information acquired at Government expense."

• **Council membership**—Co-chaired by Assistant Secretaries of Defense Eugene G. Fubini (Dept. Dir., Defense Research and Engineering) and Thomas D. Morris (Installations and Logistics), the Council will draw its membership from the assistant secretaries for research and development and installations and logistics within the three services.

Specifically, the responsibilities of the Council are:

—To approve all projects on technical data and standardization as well as to initiate or terminate projects;

—To review the progress and results of work in these areas;

—To recommend manpower and financial requirements and organizational changes; and

—To formulate policies for the promulgation through DOD directives and instructions and revisions to the Armed Services Procurement Regulations.

Although numerous programs are already under way within DOD to improve procedures for acquistion of technical data—and many more are planned—the annual cost of the program makes it essential to focus special emphasis on this area, Defense officials feel.

DOD practices in acquiring, using and disseminating scientific reports, development and test reports, drawings standards, specifications, technical manuals and other technical information will come under the purview of the council.

James W. Roach, assistant director for engineering in DDR&E, has been appointed vice chairman of the Council and will devote his primary time to coordinating the efforts at the OSD level. In addition to DDR&E and I&L, Roach will oversee the logistic services function of the Defense Supply Agency as it pertains to administration of the Defense Standardization program, planning for item-entry control and future improvements in cataloging defense materiel.

Monthly reports to Deputy Secretary Vance on the Council's progress are required. The first report is due April 15.

• **Defense-Commerce pact**—In a related development, DOD and the Commerce Dept. announced a working agreement under which the Office of Technical Services in the Commerce Dept. will process the 20,000-30,000 unclassified reports produced each year by DOD.

OTS, beginning May 1, will catalog the reports, program them for retrieval through DDC's automated system, and distribute them to DDC-OTS users. The joint venture is the initial step toward a more unified Federal document distribution system. ■

At procurement seminar . . .

Demler Warns of Tight Controls on R&D

TODAY'S ENVIRONMENT in government research and development will not tolerate organizations that have ill-defined objectives or vague aims for exploratory development and advanced development programs. Nor can organizations expect to survive if they continually have gross overruns, ballooning costs or overlapping management.

These points were strongly emphasized by Maj. Gen. Marvin C. Demler, commander of the Air Force System Command's Research and Technology Division, in the keynote speech to a three-day Research and Technology Procurement Management Seminar in Santa Monica, Calif.

Noting the increased interest of Congress in government R&D expenditures—evidenced by the creation of three new committees to study R&D and the proposal to create a Congressional Office of Science and Technology (COST)—Demler emphasized that "these actions make it imperative that we renew and continue to maintain an atmosphere of cost awareness both in the management of in-house research programs and operations, as well as our contractual research relationships."

To further illustrate his point, Demler noted President Johnson's commitment that the government will get a dollar's value for a dollar spent, as well as the President's unprecedented move of sending 7,500 letters to industry enlisting their help.

• **Constructive steps**—Through the improvement and modernization of research procurement management, the Air Force hopes to:

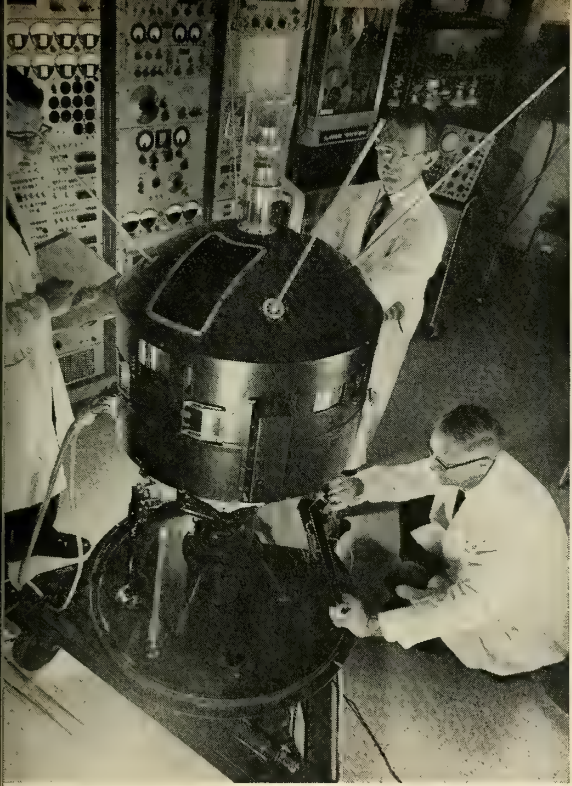
—Accelerate the productivity of Laboratory personnel by providing more responsive procurement support and increasing the understanding of today's total R&T procurement environment;

—Acquaint participants with the major research procurement problem areas and requirements for improvement in the management of R&T projects and programs; and

—Provide an understanding of how creative thinking and managerial skills and techniques can be applied most efficiently to bring about the early acquisition and application of the technology necessary.

• **Flexibility is goal**—In contracting for exploratory and advanced development projects, the goal will be maximum flexibility—both in contractual form and in method of contracting. Negotiation will, therefore, be the preferred method in these two categories.

Demler said incentives will be applied not only to cost but also to such things as "continuity of effort, recognition, facilities" and any other identifiable assets. ■



UK-2 SATELLITE, shown without its electric power-producing solar paddles, gets final check at Westinghouse.

'Topsi' postponed . . .

UK-2 To Measure Galactic Noise, Ozone, Particles

U.S.-built satellite carrying British experiments is second in joint series initiated by still-functioning Ariel I

NASA THIS WEEK will attempt to launch the second of three satellites in its joint space exploration program with the United Kingdom.

The *UK-2* satellite, built in the U.S. but carrying British experiments, is scheduled for launch with a *Scout* booster no earlier than March 26.

At the same time, the space agency announced that the March 18 launch of another *Scout* booster payload, the *"Topsi"* satellite, has been postponed indefinitely because of persistent difficulties with the launch vehicle's electrical wiring.

The delay will not affect *UK-2,* the space agency said, because its launch vehicle has checked out satisfactorily.

The 150-lb. *UK-2* will be launched from Wallops Island, Va., into an orbit with an apogee of about 930 statute miles and a perigee of 170 miles. Planned lifetime for the 23-in.-dia. spacecraft is one year.

Three experiment packages on board the satellite are designed to measure galactic radio noise in the frequency range of 0.75 to 3.0 megacycles, vertical distribution of ozone in the atmosphere, and the number and size of micrometeoroids in space.

The first experiment, built by the Mullard Radio Astronomy Observatory, University of Cambridge, is designed to provide data for radio astronomers. The astronomer "sees" distant stars and galaxies by picking up the signals they emit with the antenna of his radio telescope. Some of these signals from interstellar space, however, cannot penetrate the ionosphere—the blanket of charged particles encircling the Earth—and as a result the radio astronomer has very little information on them. The galactic noise experiment aboard the satellite will help fill this information gap.

The ozone-measurement experiment, supplied by the British Air Ministry's Meteorological Office, is important because it is believed that ozone distribution affects the Earth's heat balance and, therefore, its weather.

- **Combined operation**—The U.S.-U.K. International Satellite Program is being conducted jointly by the U.K. Ministry for Science and NASA. The British designed and constructed the instrumentation for the *UK-2* experiments under technical management of the U.K. Space Research Management Unit.

The first international satellite, *Ariel,* was successfully launched by NASA with a *Delta* vehicle from Cape Kennedy on April 26, 1962. *Ariel,* which is still sending information from space, carried six British experiments designed to obtain information on cosmic rays, electron density, electron temperature and concentrations, the ion mass spectrum, solar X-rays and the ultraviolet spectrum.

If *UK-2* achieves orbit, it will be known as *Ariel II.*

The third satellite in the series, *UK-3,* will be built by the British. No date has been set for its launch.

That satellite will carry five experiments—including measurement of vertical distribution of molecular oxygen in the Earth's atmosphere, large-scale noise in the galaxy, intensity of VIF radiation, intensity and geographical distribution of natural terrestrial noise sources, and electron density and temperature.

Westinghouse Electric Corp., under the direction of Goddard Space Flight Center, is responsible for system integration of all satellite system elements and for final design, analysis and fabrication of the satellite structure itself.

Westinghouse furnished the power supply subsystem and the telemetry encoder subsystem. It also designed and constructed test stand and data-reduction systems, ground handling equipment and special test equipment.

Overall direction of the project is provided by the Office of Space Sciences of NASA headquarters, representing the United States, and by the British National Committee on Space Research, London. ■

Ball valves for airborne and support applications

8 inch full ball valve. Hermetically sealed for zero leakage. Secondary seal has low leakage rate of 15 cc Freon per minute at 900 psig. Handles nitrogen tetroxide.

12 inch segmented ball valve. Leakage rate of 30 cc gaseous nitrogen per minute at 54 psig. Handles RP-1.

17 inch segmented ball valve. Flows 40,000 gallons per minute of liquid oxygen. Leakage rate is 328 cc gaseous nitrogen per minute at 185 psig.

Garrett-AiResearch ball valves can be designed to handle all liquid missile fuels and oxidizers, both cryogenic liquids and gaseous forms, from —425°F to +400°F. Sizes are programmed from 2.5 to 50 inches in diameter. • In applications calling for large diameter valves and/or low pressure, a segmented ball is utilized; for small diameter and/or high pressure uses, a full ball is used. The seals are stationary. Technical superiority, reliability and minimum seal wear are achieved by using simplified actuation devices. A significant number of moving parts are eliminated and weight is reduced. • The ball valve line is the newest addition to a complete line of AiResearch precision valves, including both butterfly and poppet types. • Please direct inquiries to AiResearch Phoenix division.

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ELECTRONICS

Patrick Gets New Digital Trackers

The new Contraves Cinetheodolite, provided with a digital azimuth and elevation readout and a semi-automatic film reader, will permit a decrease in film-reading time from 50 seconds/frame (for conventional systems) to 0.8 second. Supplied by the I.W. Fecker Division of American Optical Co. to the Air Force for use on the Atlantic Missile Range, the Model E employs a patented dual-circle-projection, digital, optical encoder. The output is recorded on each film frame. The result is a determination of tracking error.

Second Major LPS Contract Awarded

A $319,150 contract to build the electrical drive system for NASA's new Launch Phase Simulator has been awarded to Allis-Chalmers. Prime contractor for the $4-million facility, to be operational at Goddard Space Flight Center late in 1965, is the Northrop Corp. The new award, let directly by NASA, calls for development of two 1,250-horsepower vertical dc motors, a 2-kw motor generator set plus drive system controls. When complete, the massive centrifuge (230 tons, 60-ft arm radius) will be driven at speeds up to 34 rpm and develop accelerations up to 23 g's. Carrying a 2-ton payload, measuring up to 15 x 10 ft. in diameter, the system will stimulate launch-phase acoustical and vibration effects to test unmanned space vehicles (See M/R, Nov. 25, 1963, p. 196).

Navy Fire Control May Go Digital

An experiment presently being conducted at Naval Ordnance Test Station, China Lake, Calif., may pave the way for the introduction of digital fire control systems throughout the Navy. Twenty-one military personnel, ranging in rank from seaman striker to lieutenant (jg), and one civilian, are completing a course at NOTS on 'Basic Fire Control Digital Techniques,' the first of its kind ever conducted by the Navy. Soon, they will operate an experimental digital fire control facility at the station's Guidance Radar branch of the Test Dept. and, according to Navy officials, on the basis of their success with this assignment is hinged the fleet-wide application of such equipment. The training curriculum, prepared by the Navy *Typhon* Training Unit, Baltimore, Md., covers transistor theory, number systems, Boolean algebra, basic digital circuits, basic digital computer, fundamentals of programming and peripheral equipment.

EOS Gets New Mariner Power-Cell Contract

Solar panels for the *Mariner*/Mars spacecraft will be built by Electro-Optical Systems, Inc., Pasadena, Calif., under a $200,000 contract to Jet Propulsion Laboratory. Each of the 11 panels to be built will measure 3 x 6 ft. and will contain some 7,050 silicon cells. The panels will be folded into a vertical position for launch and released by squibs after the spacecraft separates from the launch vehicle. EOS produced the power control units for *Mariner II* and the solar power systems for the *Ranger* Block III spacecraft.

Small Thermionic Converters Pass Life Tests

Five thermionic converters, built and tested by Thermo Electron Engineering Corp. for Jet Propulsion Laboratory, have successfully completed 3,000-hr. life tests. Average power output reduction throughout the test period was about 10%, the Waltham, Mass., company said. Designed for use in solar-activated space power supplies, the half-pound devices will be employed in future NASA space missions. A complete solar generator will employ from four to five converters and is expected to produce from 100 to 200 watts.

Precedent-making Guarantee Offered

Westinghouse JEDEC-registered silicon power semiconductors (including rectifiers, controlled rectifiers and transistors) hereafter are guaranteed for the "life of the original equipment in which they are used," the manufacturers announced recently. Such devices previously were provided with a one-year guarantee.

ASTRONAUTICS

Device Flips Lid, Could Explore Moon

Engineers at Space-General Corp., California, see high promise in a new unmanned exploratory vehicle they call the "Tumbling Explorer," which, developers claim, could negotiate the sort of rugged terrain man can expect to find on the Moon and planets. Dubbed TEX, it is the outcome of a novel approach to locomotion centered in a device rather like a clamshell in appearance—it moves by "flipping its lid." Its basic structure is simply two panels housing a radio-controlled drive mechanism which achieves motion by toppling one panel over the other in successive cycles. TEX, the company claims, may be steered in any direction and could move up to 36 feet per minute. An operational version could carry a vidicon television camera in each panel and could be dropped onto the lunar surface by an unmanned spacecraft. It would measure 3 x 5 x 1 ft. Power would be drawn from solar cells.

PROPULSION

Nerva Liquid H_2 Cold Flow Tests A-OK

First cold flow test of the Aerojet-Westinghouse-built NRX-A1 reactor assembly for the Nerva nuclear rocket engine using liquid hydrogen under pressure was made successfully at the Nuclear Rocket Development Station, Jackass Flats, Nev., last week. The system operated "just as programmed," a spokesman said, and initial indications are that there was virtually no occurrence of the troublesome vibration problem that has plagued development of the Kiwi reactors in the past. Design of the cold-flow NRX/Nerva reactor experiment/reactor is based on the modified Kiwi B4-A (designated at B4-D) and, like the D model Kiwi, has a strengthened core support structure and hot-end seal, designed to eliminate the flow-induced vibrations experienced during hot-power runs of the Kiwi B4-A in November, 1962. During this week's test, cold gasses and liquid hydrogen at —420° F were directed under pressure through the NRX-A1 core, and preliminary analysis and visual observation indicated no vibration whatever. "Hot" versions of both the NRX and B4-D reactors are now being assembled at NRDS and are scheduled to go through a series of "hot" tests during mid-summer. The B4-D may make its first hot run toward the end of next month. The NRX-A1 will undergo further cold-flow tests in coming weeks before it is disassembled for visual observation.

Two New Labs To Sharpen Aerojet's Solid, Liquid Capabilities

$6-million cryogenics facility already at work on NERVA, M-1 engine programs; can accommodate three liquid gases

by Willard E. Wilks

SACRAMENTO, CALIF.—Aerojet-General Corp. is establishing new capabilities in advanced liquid and solid rocket development with two new laboratory facilities in this area.

Now about 95% equipped and at work on the NERVA and M-1 engine programs is a unique $6-million cryogenics laboratory at the liquid rocket plant near Sacramento. Working with three liquid gases, the lab is equipped with unusual pressure and flow capabilities to meet needs of the two projects.

The other new facility is a materials and fabrication R&D laboratory at Aerojet's downtown Sacramento installation. Nearing full operational status, the lab is oriented toward basic work and entirely devoted to solid rocket research requirements.

- **Exploiting NERVA-M-1 "commonality"**—The cryogenics lab manager, R. C. Kuhlman, told MISSILES AND ROCKETS the facility is taking advantage of hydrogen "commonality" in the NERVA and M-1 projects to produce important cross-fertilization as well as major savings in equipment and in R&D time and money.

Detailed technology in design of NERVA's liquid hydrogen turbopump radial and axial bearings, lubricated and cooled by the propellant, has been found directly applicable to the 1.5-million-lb. thrust M-1. "We simply extrapolated up to the size of the bearings required," Kuhlman said. "We were able to develop the larger size bearing in short order due to our experience on the smaller-scale NERVA."

Other NERVA developments applicable to M-1 design include valve components and rotating and static seals. Heat transfer studies on the regeneratively cooled NERVA thrust chamber also will apply to M-1 development.

- **Simulation saves money**—The cryogenics lab is designed to save money in development by proving out individual components and systems in simulated environments before committing a full scale engine to test firing.

"With an engine the size of the M-1, the engineering and fabrication time involved in making parts is prohibitive," Kuhlman said. "It is impossible to go the route of building whole components. We have to know first whether something is workable from a materials and design standpoint. That is the value of the lab."

On the M-1, the laboratory is testing hydrogen-oxygen engine components at 7.5 times the size previously undertaken. M-1 and NERVA components will operate under the highest flow rates and design pressures ever attempted in this country in liquid engines.

The two engine programs currently provide the lab's major work, with some classified effort underway on high-chamber-pressure rockets. Both engines are in component development stage, with NERVA farther along because of its earlier start. Some M-1 components have moved out of the facility for hot firing, and the lab is now working on some prototype-size M-1 components.

One of the main ideas involved in design of the cryogenic facility was cross-fertilization between development programs. The installation originally was planned for NERVA, but with the ability to expand in event the company received the M-1 work. Some of the larger facilities being shared include a 3-ft.-dia. spin pit in which rotating components are tested to destruction, a 6 x 8-ft. space simulation chamber, and a 10,000-lb. sine and random wave vibration tester.

- **Cryogenics lab facilities**—The lab has 11 test bays, including two liquid oxygen and three liquid hydrogen bays for M-1, and six liquid hydrogen bays for the smaller NERVA. One of the test bays used for M-1 component testing is large enough to test the entire M-1 thrust chamber assembly, which is 17 ft. in diameter and 26 ft. high. The bay is 30 x 50 ft. and is equipped with a 10-ton crane with a hook height of 30 ft. In all bays, a number of tests can be put simultaneously in set-up, test and tear-down stages.

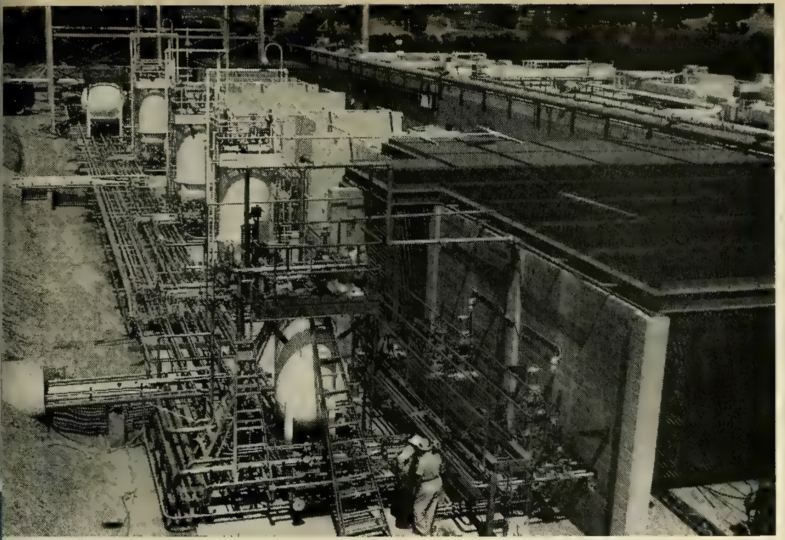
The cryogenic installation is unique in a number of other ways:

—All recording and signal conditioning equipment is integrated into one complex, eliminating equipment duplication. Each test bay can be patched into the central patch board, permitting an 11-fold capability.

—Use of pre-programmed patch boards and plug-in test carts for each test setup allows unusual flexibility. One test can be set up while another is underway, cutting the time required for designers to obtain data and permitting a heavier work load.

—A key piece of operational philosophy is that the design or development engineer personally directs subcomponent testing and often conducts testing himself. The lab has no test engineers per se, providing instead the consulting services of specialist engineers in such fields as high-vacuum, vibration, cryogenics and rotating machinery.

"This laboratory represents a great



CRYOGENICS laboratory nears completion at Aerojet-General's liquid plant near Sacramento, Calif. NASA-financed facility is testing M-1, NERVA engine components.

increase in our capability of testing subcomponents with cryogenics under simulated operating conditions," Kuhlman said. "We can get a good indication of how bearing and seal designs work without building the whole pump. A valve will be taken right off the design board and fabricated out of bar stock or a casting for initial development tests. When we finally design a valve, we may investigate eight or nine different seal configurations and build a seal tester rather than the whole valve."

Bearings can be tested without building an entire power transmission assembly. To simulate accelerations the lab uses a 500-hp steam turbine, boosted by a flywheel and planetary gear up to the equivalent of 5,000 hp.

- **One-complex testing**—The lab incorporates most of the basic test capabilities it requires into one complex. Materials, subcomponents and systems can be tested with cryogenics under vacuum conditions at altitudes corresponding to 1×10^{-7} mm Hg. Three test bays are equipped with materials test cells. The lab handles irradiated components after sending them out for irradiation.

Space chamber design provides for addition of solar simulation pattern test equipment if needed. An integral part of the chamber is a leak detector tuned to hydrogen.

The facility has 10,000 sq. ft. of floor space under-roof and about the same amount devoted to adjoining open test-pad area. The test-pad complex is divided into five sub-complexes, with the 11 test bays arranged with "T" section protective walls separating them. Each sub-complex is an independent unit with separate run tanks, control consoles, and instrumentation terminal boxes. Basic instrumentation and propellant tankage are common systems.

A packed-earth revetment separates the test complex from the liquid and gaseous storage tanks, which include 13,200 gal. of liquid hydrogen, 13,200 gal. of liquid nitrogen, and 5,000 gal. of liquid oxygen. Two closed circuit TV systems provide remote observation.

- **Materials and Fabrication lab**—The materials and fabrication R&D laboratory, with which Aerojet is aiming for a top position in the advanced solid field, actually is two labs—applied R&D and basic research. The lab is conducting work in metallography, physical test, chemical analysis, synthesis, fabrication development, failure analysis, and basic research to develop new materials.

Covering an impressive 60,000 sq. ft., the laboratory is unique, says manager A. V. Levy, "in that applied R&D and the basic research group are physically next door to each other, so that the basic work will be oriented toward the needs of company products rather than being completely exploratory and undirected in nature. We keep them separated, but with a thin wall between so that basic research won't be unnecessarily diluted by the everyday needs of the company. Some companies have found that everyday needs are so great that the basic research people have no time for the basics. The trick is to separate the two, but not too far."

- **New facility for basic research**—The new basic research facility, still being created, is based on three disciplines,—physical chemistry, physics and metallurgy. Research programs planned include application of solid-state physics methods to the problems of brittle fracture in tungsten. Work in dislocation mechanics and fracture geometry will be directed toward exploiting the intrinsic strength of tungsten.

Other basic research projects include determination of ternary and quaternary phase diagrams for refractory metal-carbon systems, investigation of the effect of static stresses on damping and dislocation-interstitial interactions in refractory metals, and measurement of the surface energy of tungsten.

- **Applied R&D in process**—Applied R&D programs include development of advanced infiltrant-cooled tungsten nozzle materials, fabrication development of columbium alloy nozzle exit cones, investigation of chemical erosion of graphite in nozzles, determination of char strengths of ablative plastic nozzle components, development of fusion welding techniques in joining 18% nickel maraging steel plate, investigation of optimum filament winding patterns for glass reinforced chambers, development of advanced castable chamber internal insulation.

In its chemical erosion studies, Levy reports the materials and fabrication lab has found that erosion of graphite subjected to high-temperature gas flow is not a function of the temperature breaking down the material, but rather a matter of chemical reactions between compounds in the gases and the carbon atoms in graphite.

The materials analysis section of the laboratory contains complete metallographic, materials analysis and materials synthesis facilities. Complete facilities are available for quantitative and qualitative analysis of all metallic and nonmetallic inert component material. The section also contains blenders, mixers, mills, screening and grading equipment and associated laboratory bench-type equipment for compounding metallurgical powders and elastomers.

Machinability research is underway in the fabrication processes section, which contains complete facilities for joining and forming. Extensive forming facilities include 50- and 200-ton hydrostatic hot and cold forming presses and shear and conventional spinning machines capable of spinning thick-section refractory metals. A fully instrumented machinability lathe permits studies of forces, tool designs, cutting fluids and speeds and feeds associated with exotic materials.

Complete physical and mechanical properties determination equipment includes tensile and compressive stress equipment with maximum capabilities of 120,000 lb. and facilities for creep, torque, bending, flexural, and subscale and full-scale impact testing from ambient temperature to 6,000°F, utilizing conventional atmospheric and electron-beam furnaces. ■

IMP Discovers New Radiation Belt

Presents no danger to space travelers; standing shock wave is detected for the first time

by William Beller

DATA FROM EXPLORER XVIII is showing the Earth swaddled in a layer of energetic particles wrapped around the magnetosphere. Unlike the Van Allen radiation belts, the newly authenticated one is not expected to endanger astronauts.

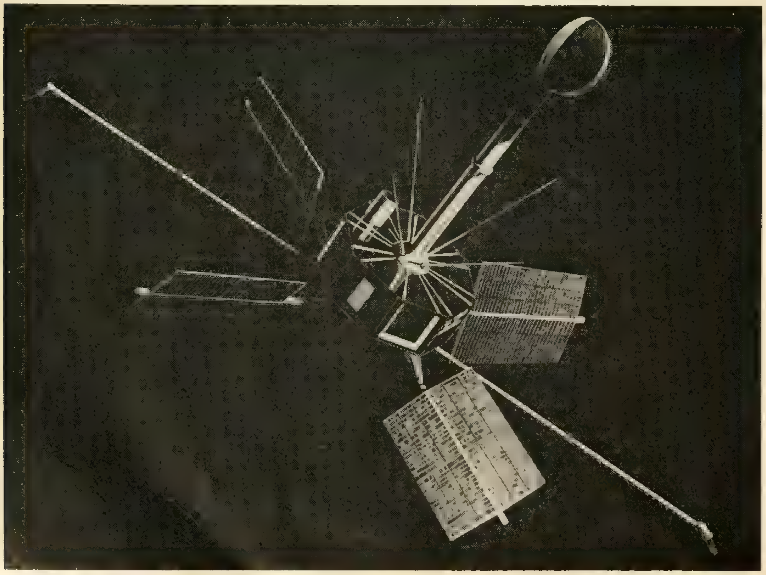
Alternately known as *IMP 1* (*Interplanetary Monitoring Platform*), the satellite is ranging wide in near-Earth space bringing in data that may bear on the source of magnetic storms and is giving a downward extension of the energy of helium in interplanetary space. Four more *IMPs* are scheduled to be launched.

The revised picture of space around Earth was drawn by eight experimenters reporting on their preliminary findings to 500 scientists at an *IMP* meeting held recently at Goddard Space Flight Center, Greenbelt, Md. The report was based on the first 70 days of *IMP*, or 19 orbits. During this time, the satellite's apogee lay almost entirely on the sunlit side of Earth.

In January, the apogee moved far out behind the Earth, thereby opening up a virtually unexplored region of near-Earth space. Here the tail of the magnetosphere will be studied as well as the "shadow" effect of the Earth on the solar wind and interplanetary magnetic field.

- **Earth in supersonic flow**—Seeming to duplicate the flow pattern of a sphere in supersonic flow, the solar wind forms a standing shock wave as it streams around the Earth's magnetic field. Although this phenomenon has been predicted by many space scientists, IMP has provided the first experimental evidence that the shock wave exists.

"BASKETBALL" at end of large boom is IMP's rubidium-vapor magnetometer. "Microphones" at ends of two smaller booms are fluxgate magnetometers.



The solar wind, sometimes called solar plasma, flows continuously from the Sun as a steady stream of very-low-energy charged particles. Thought to travel at speeds up to 300 mi./sec., the plasma has a density of about 10 particles/cu. cm. at the orbit of the Earth.

Some scientists believe that the solar wind is simply the tenuous extension of the Sun's atmosphere or corona into interplanetary space. And they support this view by noting that during periods of high solar activity or flares, the speed of the solar wind goes up.

One of the impressive effects of the solar wind is that it apparently shapes the boundaries of the Earth's magnetic field or magnetosphere into an airfoil-like shape. Its leading edge, which lies on the Sun-Earth line, is about 40,000 miles out from the Earth toward the Sun. The trailing edge fades away at some yet unknown distance away from the Earth. "The mapping of the backside of the magnetosphere, and determining its composition, is one of the major scinetific objectives of the IMP program."

- **Regions around Earth**—In plasma measurements made by a Massachusetts Institute of Technology sensor, the shock front was pegged a few Earth radii in front of the magnetosphere's leading edge. The M.I.T. device permitted particles to enter a 6-in.-dia. surface through a series of grids that separates electrons and low-energy positive particles. In this way, the instrument is able to determine the flux, speed and direction of motion of the particles analyzed.

On the basis of these data, M.I.T. experimenter Herbert S. Bridge describes three distinct regions surrounding the Earth:

The inner region, corresponding to the Earth's magnetic cavity, is characterized by an absence of low-energy plasma. It extends about ten Earth radii in the direction of the Sun.

The second region, the "shock" region, contains hot turbulent plasma. The outer boundary of this second region marks the transition between "supersonic" and "subsonic" flow and is the shock front.

The plasma in the third, or outer, region, is observed to be relatively mono-energetic and with a velocity directed away from the Sun. The observed particle density and velocities indicate a "supersonic" flow relative to the Earth.

- **Shock front varies**—Plotted on a counting-rate-versus-distance curve, the shock front appears as a clear "spike" on the Sun-Earth line. The shock front becomes increasingly blurred when observations are made at further distances from the Sun-Earth line. In addition, the thickness of the region of turbulence or transition area increases. For example, on a line at right angles to the Sun-Earth line, the distance between the shock front and magnetopause has increased up to 8 to 10 Earth radii.

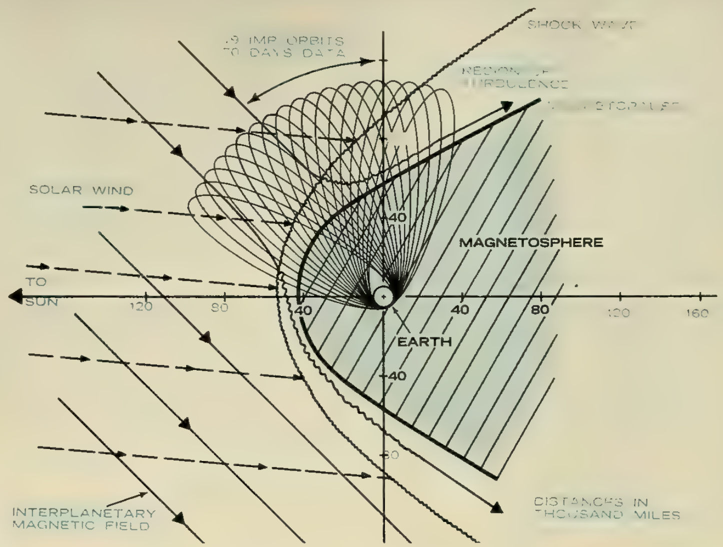
The extent of the transition area suggests to Kinsey A. Anderson, University of California (Berkeley) experimenter, that the Moon may be peppered with high-energy radiation particles during a portion of each monthly lunar orbit. Because of the sparseness of these particles, it is not felt they will cause any hazard to lunar astronauts.

The magnetopause by definition is the outer boundary of the magnetosphere and, correspondingly, is also considered to be the boundary of the Van Allen radiation belts. Anderson asks whether the transition region may now be called a part of the radiation belts.

Anderson observes that so far the data from *IMP* show virtually no high-energy particles on the Sun's side of the shock front—when the satellite had passed beyond the radiation belts and into the solar wind of interplanetary space.

He takes this as "an indication that the high-energies (of the particles) do not originate at the Sun, but are rather 'born' in the interaction between the solar wind—formed largely of protons and lower-energy electrons—and the Earth's magnetic forces."

Anderson's theory, labeled "highly speculative" by Frank B. McDonald, *IMP* project scientist, Goddard Space Flight Center, admits that the mechanism for accelerating the electrons within the transition region is still unknown. Nevertheless, data from the experiment "suggest" that about half of the high-energy electrons find their way into the 'trapped' regions of the Van Allen radiation belts and are later lost into the Earth's atmosphere," Anderson argues.



FIELDS and radiations in the ecliptic plane of cis-Earth space. Note the 19 orbits of IMP shown spiraling across the region of turbulence.

The scientist sees the other high-energy electrons remaining outside as "transient radiation, to be sluffed off the sides of the radiation belts and to trail out in the 'wake' that is carried in the current of the solar wind."

Anderson confirmed the conclusions of other *IMP* experimenters that the amount of high-energy radiation involved in the region beyond the Van Allen belts do not hold any serious hazard for space travelers. He cited the instance of a solar storm last December 2, which "did not add high-energy particles to the solar wind."

The storm, though, did unload some of the particles trapped in the radiation belts, presumably as a result of the accompanying temporary changes in the Earth's magnetic lines of force.

- **Source of magnetic storms**—Experimenters of the University of Chicago discovered a flux of low-energy protons emanating from the Sun in a 90-degree segment and rotating with the Sun. In a paper delivered by John A. Simpson, he said "the region has reappeared for three successive solar rotations and the stream of protons (approximately 1 Mev) falls within the enhanced solar wind beam postulated to account for the 27-day modulation of galactic cosmic-ray intensity by the Sun." Simpson said the rotating segment may be the explanation of recurring magnetic storms on Earth.

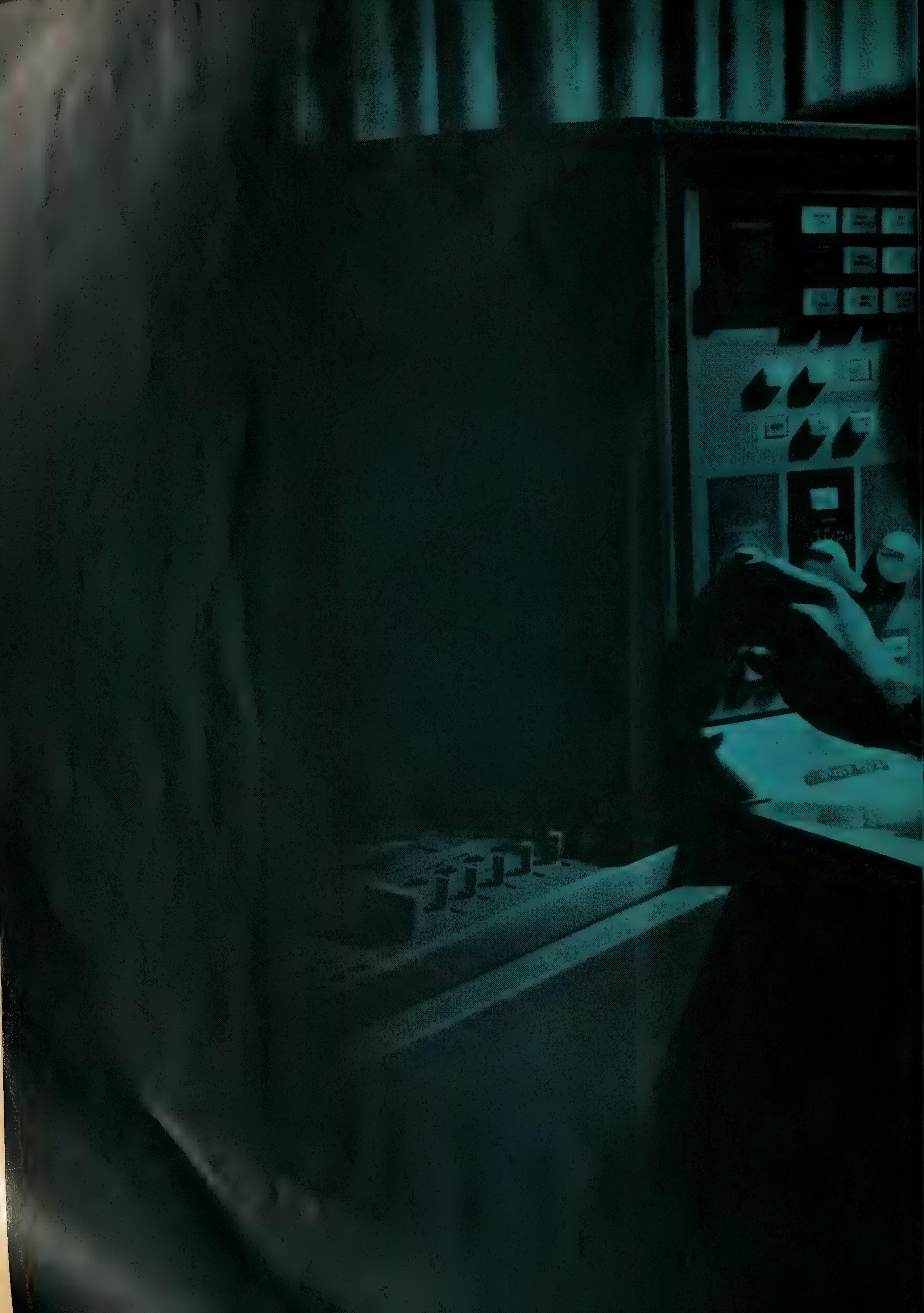
The University of Chicago scientists also measured in interplanetary space a flux of helium nuclei covering the energy range from 8-80 Mev/nucleon. This is said to represent an order-of-magnitude downward extension of the helium spectrum previously reported.

Simpson said it is likely that the shape and persistence of the energy spectrum indicates that the nuclei are of galactic origin and are reaching the inner solar system at this time because the Sun is near its minimum in the solar cycle.

IMP has already "paid its own way." A Goddard scientist also suggested that the satellite might soon draw the major structure of the radiation and magnetic fields in the Earth's near space. It may also provide a key to the theory of solar flares. ■

EXPLORER XVIII: INTERPLANETARY MONITORING PLATFORM

Launch:	Nov. 26, 1963 at 9:30 PM (EST) Atlantic Missile Range on Delta rocket
Apogee:	122,800 stat. mi.
Perigee:	120 stat. mi.
Inclination:	33.3°
Period:	3 days, 22½ hrs.
Velocity:	24,300 mph at perigee; 780 mph at apogee
Weight:	138 lbs.
Main structure:	Octagon, 28 in. x 28 in.; 12 in. deep
Appendages:	Four solar paddles, 26 in. long x 18 in. wide Four antennas, 16 in. long Rubidium-vapor magnetometer, on 6 ft. boom Two Flux gate magnetometers on 7 ft. booms



Command & Control Laboratory

Now in operation at Lockheed Missiles & Space Company is a model Command & Control system for a world-wide satellite network. The real thing in every sense—except that the inputs from its "tracking stations" are simulated on tape—it is striking at the crux of the Command & Control problem: how to analyze, synthesize, and display a torrent of data—in real time—so The Commander can instantly make the right decision. And it is giving Lockheed's scientists and engineers the solid answers that are needed to cope with the increasing complexity of Command & Control. Lockheed Missiles & Space Company, Sunnyvale, Calif. A Group Division of Lockheed Aircraft Corporation. **Lockheed**

Haystack Antenna May Go On in July

Dish assembly now completed; static load tests under way; major gains expected; West Germans said to be interested

by Michael Getler

TYNGSBORO, MASS.—With the last of 96 aluminum honeycomb antenna panels now in place, and final acceptance tests under way this month, the Air Force/MIT Lincoln Laboratories/North American Aviation, Inc. team putting together the massive 120-ft. Haystack antenna system here now estimates the experimental facility should be "on the air" in July.

While the system will take part in a wide range of radiometric, radar, and communications research, some of its earliest efforts will be aimed at further exploitation of the AF-Lincoln Labs Project West Ford experiment.

Haystack, hampered by cost overruns (total AF-Lincoln Labs cost now is estimated at $13-14 million at completion) and delays of some 18 months in getting on the air, nevertheless is expected to become one of the most significant advances in microwave radar. Scientists here claim the system will be at least three orders of magnitude more sensitive than Haystack's predecessor at Lincoln Labs—the high-power 84-ft.-dish Millstone Hill radar, located nearby—and possibly some 5 to 6 times more sensitive than other more typical UHF radars.

"There isn't anybody who has touched this program that's made money," says one project officer, "yet it's a giant step forward."

Cost of the Haystack project is being borne by both Lincoln Labs and the Air Force's Electronic Systems Command (ESD). Lincoln Labs will operate the antenna system and also serves as technical monitor.

● **Near-perfect X-band antenna**—The expected broad state-of-the-art advance signaled by Haystack operation is, in fact, due not to a single breakthrough but rather to an effort to push the technology ahead by several factors in each of the contributing technologies. As a result, one top scientist here points out, the piece parts actually are 5-10 times better than the aggregate, and yet the aggregate will exceed by a significant factor anything that is currently available.

For example, the 18-bit shaft encoder that operates with the Haystack system is pointed out as a unit that is pushing the state of the art. Developed by Telecomputing Corp., it is reported to narrow the degree of shaft position uncertainty to about 2.4 seconds of arc, or about .00066 deg.

Scientists here predict that at its nominal design frequency of 10 Gc, Haystack "will be the most perfect X-band antenna of large size in the world." Its precision for operations in the 10 Gc region is also expected to give the antenna considerable capability for radio astronomy experiments to frequencies to perhaps 35 Gc at certain elevation (45 deg).

The Haystack Cassegrainian-feed antenna, being built by the Columbus, (Ohio) Div. of NAA, has a 120-ft.-dia. parabolic-axial load primary reflector made up of 96 ½-in.-thick aluminum honeycomb panels. The maximum deviation from the true contour of the dish at any elevation angle is designed to be within ± 0.075 in., one of the major advancements in large dish design. This means that loads imposed by gravity or thermal effects, manufacturing errors, measurement errors, or field erection and checkout discrepancies can be cumulatively kept to within the 0.075-in. total uncertainty.

At 10 Gc, the 120-ft. Haystack aperture will yield a half-power beamwidth of 0.05 deg, about 40 times as narrow as the 2-deg beam of the Millstone Hill UHF radar (the Millstone Hill beamwidth is three times as narrow in L-band operation as it is in UHF). The maximum pointing error or angular uncertainty at low tracking rates (1 deg. sec.) should not exceed ± 0.005 deg., according to Lincoln Labs, with a slightly higher figure of ± 0.012 for the higher tracking rates.

Theoretical gain of the system operating at about 8 Gc, according to scientists here, will be 67-68 db. Contributing factors, in addition to the extreme sharpness of the beam, include the use of the Cassegrainian optics, lack of significant lengths of waveguide, reduction in rotating joints, ability to put receiver components close to the dish, and introduction of very-low-noise receivers.

Initially, Lincoln Labs says, cooled parametric amplifiers used in the receiving system will yield an overall system temperature of 70-80°K. Within a few months, the Labs expect to introduce a closed-loop cryogenic maser amplifier that will bring system temperature down to about 30°K, some 5-6 times below current typical UHF radars. Sky temperature background will not be a problem at these temperatures.

At X-band, the Haystack dish-diameter/wavelength ratio is leading the field, scientists here report (see chart on p. 28). Where figures in the 100-200 region were characteristics a few years ago, Haystack is pushing into the 3,000 region.

- **Millstone comparison**—Haystack will be able to skin track an unaugmented 1-sq.-meter target out to ranges of 16,000 miles, in comparison to 2,000 miles for the Millstone radar, still one of the most precise in the world. Probably more important, however, is the ability of Haystack to see a target with three orders-of-magnitude less cross-section at 2,000 miles.

In addition, whereas the Millstone radar, under certain conditions, has "just about been able to bounce radar signals off Venus and receive echoes," the Haystack antenna is expected to expand the time and conditions during which Venus can be viewed as well as increase the S/N ratio. It also will provide the means for similar experiments to be made with Mars and Mercury, and possibly with Jupiter and Saturn.

Ability to perform in this manner is also in large measure attributed to the controlled environment in which Haystack will operate. The entire antenna system is housed in a huge 150-ft.-dia., 134-ft.-high radome, believed to be the largest metal-space-frame radome of its kind. The 171-ton radome supplied by the Plastics Div. of the H. I. Thompson Fiber Glass Co., consists of hollowed aluminum beams, up to 15 ft. long, which support glass-fiber-reinforced plastic membrane panels mounted on the frame. The panels are 1/32 in. thick.

"The transmission loss on the radome," says Herbert G. Weiss, associate head of Lincoln Labs' Radar Div., "is expected to equal about 10% of the aperture. However, this looks like a good compromise to get the environmental control and all-weather capability." Major perturbations for other normally high-precision radars often come from weather and from uneven thermal loads imposed by solar heating.

Actually, Weiss points out, the size of the radome which could be made available was really the limiting factor on the size of the Haystack antenna. "The 120-ft. dish was the biggest thing we could stuff into this radome."

- **Computer analysis**—Fabrication of a dish to a maximum ± 0.075-in. deviation specification has also brought about what scientists here consider to be "the most extensive structural stress analysis using computers that has ever been attempted."

With no real means to evaluate contractor-predicted stress levels, both NAA and Lincoln Labs launched independent computer program development with "amazingly close" answers resulting. "Reasonable concurrence between two independent groups allowed new analysis," and scientists report that differences between computed and predicted levels were on the order of .005-in. uncertainty in a 60-ft. radius.

The antenna design, NAA reports, was revised after computer analysis and evaluation and optimized at least 40 times before construction of the full-scale antenna at the Columbus facility was attempted (a scale model was built and also extensively tested). The antenna was transported in sections cross-country.

Thus far, relationship between computed values and actual measured loads also appears to be very close, according to project officials. Measurement hardware and technique is a limiting factor. A unique optical alignment probe, made by Keuffel & Esser Co., Hoboken, N.J., is aiding measurement during current static load-testing. The device uses a penta-prism arrangement to sight and read out on 1,700 target points placed around the dish.

In January, 1963, a UNIVAC 490 real-time computing system was delivered to ESD; it is now installed at the Haystack Hill site. The computer, with 12 input/output channels, will serve primarily for antenna pointing rather than for data processing. Eight celestial pointing programs for the antenna have already been developed covering West Ford, satellites, Sun, stars, planets, Moon, fixed azimuth and elevation, and fixed right ascension declination.

The secondary reflector of the Hay-

FAR LEFT: Artist's concept of Haystack shows plug-in transmitter box being hoisted into position behind dish. Cutaway shows position inside radome and small secondary reflector facing 120-ft. primary dish.

LEFT: Workmen prepare to install final panel in 120-ft.-dia. primary dish. In center is optical probe used in alignment analysis. Structural members climbing to top center position hold secondary reflector.

CHARACTERISTICS OF CONTEMPORARY HIGH-GAIN STEERABLE ANTENNAS

	DIAMETER		RMS SURFACE TOLERANCE *	WAVELENGTH WHERE TOLERANCE = $\lambda/16$ **	D/λ	BEAMWIDTH (deg)
	feet	meters				
BMEWS TRACKER	84	26	± 1.6cm	25cm	100	0.6
JODRELL BANK	250	76	± 3.0	48	160	0.4
NATIONAL RADIO ASTRONOMY OBS.	300	91	± 1.3	20	450	0.15
PARKES, AUSTRALIA	210	63	± 0.7	10	630	0.10
LINCOLN LABORATORY	28	8.6	± 0.05	0.8	1070	0.06
P.N. LEBEDEV INST.	72	22	± 0.05	0.8	2750	0.025
HAYSTACK	120	37	± 0.07	1.1	3300	0.020

*ESTIMATED WHERE EXACT DATA NOT AVAILABLE
**$\lambda/16$ CORRESPONDS TO 2.6db OF LOSS

stack system is a remotely-controlled solid-faced hyperbolic structure, 2 in. thick and 112 in. in diameter. Accuracy of this dish is reportedly within ±0.010 in.

The complete massive antenna is capable of azimuth rotation of ±300 deg, and elevation rotation from −2 deg to +92 deg. Slew rate is 3.3 deg/sec and slew acceleration is 1 deg/sec^2. Tracking rates are sufficient to track even relatively low-altitude satellites, as well as the various celestial bodies of interest.

The elevation bearing, which supports some 197,000 lbs., according to NAA, consists of four 8-in. self-aligning roller bearings. The azimuth bearing, which supports some 376,000 lbs. of rotating structure, is a steel 14-ft. combined radial and thrust hydrostatic bearing floated on a .005-in. oil film. Use of the hydrostatic bearing, supplied by Baldwin-Lima-Hamilton Corp., has allowed major power reductions for rotating the antenna.

Within the Haystack mount, all structure above the elevation axis (76 ft. up the mount) is aluminum and everything below is steel, says AF project officer Lt. John H. Shock. A Teflon sleeve is used for thermal compensation between the two metals at the axial joint.

- **Plug-in transmitters**—While a great deal of actual frequency capability will grow out of the antenna conformity tolerances, the major flexibility for Haystack is credited to the unique plug-in transmitter boxes being developed. These are 8 x 8 x 10-ft. boxes able to hold about 2 tons of equipment (cg's are identical in order not to deflect the structure) which actually are hoisted and then rail-guided into position just behind the Haystack dish. This makes it possible to interchange equipments in different frequency regions without extensive modification (it reportedly takes about ½ day to completely change over a system), allows several transmitter-receiver combinations to be used, and cuts down significantly on lengthy transmission lines and associated signal loss.

The first two boxes to go into the antenna—one an X-band transmitter and the other a radiometric system—are now in final fabrication stages. The radiometry package, designed by Lincoln Labs, will go in first and be used initially for system test and subsequently for radio astronomy. Scientists here say they hope to "take the first electrical patterns, in the 8-16 Gc region, to measure efficiency late in June or in July."

The X-band transmitter is about 2-3 months behind this schedule and is expected to be "up in the air possibly by August," Lincoln Labs reports. The transmitter program ran into considerable funding trouble, according to AF officers. The system was under contract to Energy Systems Inc. (formerly Radiation at Stanford), but AF project sources report that the contract has been terminated and Lincoln Labs will bring the components from the West Coast and put the system together here.

The X-band transmitter will be a CW system capable of being keyed for pulse-type operation. One megawatt of d-c input power can be plugged into the box, delivered in stages up to 120 kv if required.

A three-loop temperature stability system is included to keep klystron temperature constant. The transmitter was originally designed as a four-klystron system, but these have been replaced with a single 100-kw-output Varian Associates klystron tube. It is reported that this tube already has been tested at 120 kw output, operating at about 48% efficiency, by Varian.

A further advance, the development of a 300-kw tube by Eitel-McCullough, Inc., is awaited with interest here. "We may take the next step within the next year," scientists report.

The future may also see development of a high-power X-band pulsed transmitter box. "The art of high-power pulsed X-band tubes needs development," scientists here say, but they look forward to having 1 mw peak, 100 kw average power, tubes available soon.

- **West Ford use**—The X-band transmitter will be used first to detail "the fine grain characteristics" of the orbiting belt of West Ford dipoles. Scientists hope to: find out whether a thinner belt is possible with more bandwidth; study the multipath problem reduction with use of a smaller beam; and note the effect of reduced power and receiver requirements on one end with the very large dish and high power now on the other end.

This type of effort could lead to development of highly mobile truck-mounted antenna systems for use with West Ford in conjunction with a very powerful Haystack-type antenna. Current West Ford experiments are carried out with 60-ft. dishes located here and in California, with the higher-powered West Coast system said to be doing most of the transmitting.

Its use in satellite tracking will enable study of the effect of added db on the ground satellite environment. It will also allow special-purpose satellite surveillance for cross-section definition at different frequencies or highly refined trajectory data. For some satellite tracking, the Millstone radar would probably be used for initial acquisition.

The system also is expected to be used on occasion to observe Air Force Missile Test Center and Wallops Island launchings and orbit confirmation—and also perhaps for some gathering of reentry data from Wallops.

West Germany is known to have considerable interest in Haystack. Teams of scientists from that country reportedly have visited the Haystack site several times in the last few months. They are thought to be seeking a second-generation, all-purpose type of instrument able to handle both advanced comsat missions and very high-angular tracking assignments, possibly for close-in missile tracking. An initial comsat station is already being built in Germany.

The Germans are said to be particularly interested in the aluminum honeycomb structuring used in portions of the Haystack system and in the radome design. Most observers believe they will choose to build their own system rather than buy one already developed. ■

Flight Simulator Readied For Gemini Training at Cape Kennedy

by Chris Butler

CAPE KENNEDY—A versatile training device capable of simulating nearly every facet of a *Gemini* mission is nearing the operational stage here.

Engineers and technicians of NASA and McDonnell Aircraft Corp. have been working since mid-December to assemble the $4-million trainer, which will be used in the final phases of preparing astronauts for *Gemini* missions.

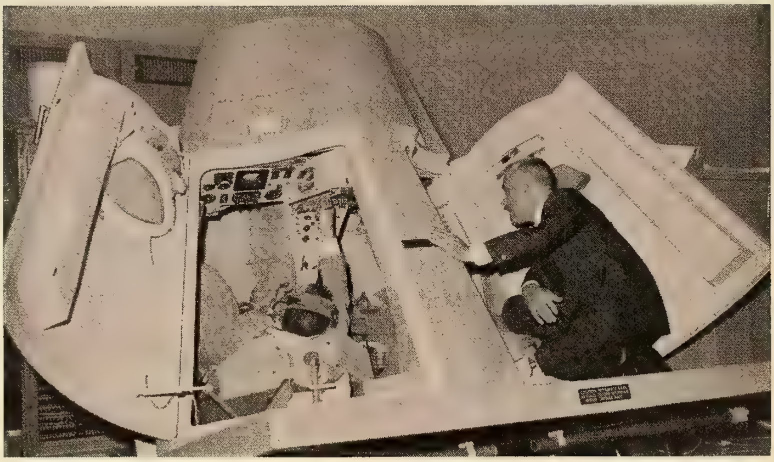
The unit, which has been installed in the Mission Control Center, is almost identical to a trainer to be installed at the Manned Spacecraft Center in Houston for use in general training of astronauts.

The flight simulator here will accomplish a dual mission by training astronauts in a specific flight plan and by verifying the operability of the flight plan for each mission. The latter will determine whether the plan includes tasks that are impossible to accomplish within an alloted time frame. Program officials activating the trainer here stressed that the facility is not being set up to test astronauts or their readiness for a flight.

Philosophy behind the mission simulator program is almost identical to that used in the *Mercury* program. Astronauts will be subjected to exercises and problems in such fields as escape emergencies, launch, rendezvous, manual retrofire and re-entry.

The training program also will include rehearsal of complete missions in "fast time," wherein astronauts will compress execution of a flight plan by eliminating all delays between required tasks. Some training missions may last as long as 48 hours.

Heart of the training operation is a full-scale capsule, which largely duplicates the pressure vessel to be used on orbital flights. It contains all the controls and displays to be found in the *Gemini* spacecraft, and will even have piped-in sounds to simulate launch and smoke to simulate an on-board fire.



PROJECT OFFICIALS check out interior of Gemini flight simulator being installed in Mission Control Center at Cape Kennedy to train astronauts for missions and to verify operability of flight plans. Hydraulic pistons move the simulator platform to give maximum tilt of 32 degrees during simulated flight. Trainer can be pressurized and simulate everything but weightlessness.

- **Digital computers used**—Two Mark I digital computers made by Link tie the two-man crew station to the instructor console and at telemetry console, which are located a few feet from the training vehicle. A switch from analog to digital computers is one of the most significant changes from the *Mercury* training program.

Spokesmen said the change was made because it reduces the extent of hardware changes required in reprogramming for various missions. They added it also is easier to find and hire digital programmers.

In operation, the astronauts will enter the spacecraft simulator and recline on couches that are tilted eight degrees above the horizontal. Hydraulic pistons can add 32 more degrees tilt to the trainer platform, bringing the astronaut couches to the 40-degree angle recommended by Manned Spacecraft Center researchers for extended training missions.

The astronauts will be able to regulate cabin temperatures when training without pressure suits and control temperatures and pressures in the suits when they are worn.

- **TV monitors**—Three television cameras will operate at all times. One will monitor the instrument panel area to watch hand movements, check timing and help lay out mission programs. The other cameras will photograph the astronauts' faces to check eye motions and assure face plates are in place and fastened before cabin pressures are changed.

The television pictures will be displayed on the console where instructors will monitor all of the simulated spacecraft and booster systems.

On the telemetry console, an instructor will be able to eliminate or override a preprogrammed problem from the computer. A total of 20 faults can be programmed, but the telemetry console can produce up to 100 problems for the men in the trainer.

In July, a housing will be added to the spacecraft simulator to provide a horizon, starfield, Earth patterns and *Agena* displays for visual training. The equipment will be mobile and will be rolled into position to cover the training vehicle.

The Cape trainer will be connected to the Integrated Mission Control Center in Houston by high-speed data links. This linkage will find additional use later on actual *Gemini* orbital flights when Cape Kennedy becomes Station No. 1 on the world-wide range for *Gemini* operations. ■

Makers Seeking Answers to Unknowns of Exploding Bridge Wire

Technical meeting shows differing opinions on merits of redundancy; Polaris, Pershing, ASSET systems described; PETN vs. alternatives

by Rex Pay

Los Angeles—Descriptions of exploding bridge wire initiators for ordnance systems in *Pershing, ASSET,* and *Polaris* given at the American Ordnance Association Joint Technical Meeting illustrate that you don't need to know how an EBW initiates detonation in order to make systems work reliably.

There was plenty of evidence, however, of active investigation of the unknowns of EBW systems, with argument centering on whether detonation is initiated by a shock or thermal wave.

In systems design, different attitudes toward the use of redundancy could be seen.

A. L. Hubbard of Lockheed Missiles and Space Co. said that a non-redundant system had been selected for *Polaris* ignition, separation, and destruct functions.

In general, he said, duplication of components reduces the probability of a "dud" firing, but increases the probability of premature firing. Redundancy is most effective when the probability of a dud is high compared to the probability of premature firing, with the tradeoff point reached when the two probabilities are about equal.

- **Non-redundancy simpler**—Lockheed found that the most obvious advantage of a non-redundant EBW system was simplification through the elimination of many components.

In the *Pershing* missile, a redundant system was selected for EBW initiation of ignition, thrust termination, and separation operations. H. R. Lowers, U. S. Army Missile Command, Redstone Arsenal, Ala., and J. M. Ashford, Martin-Marietta Corp., Orlando, Fla., explained that a development program to improve *Pershing* reliability under tactical field conditions was initiated in July, 1961. In this, the Missile Command called for a system that provided complete electronic and ordnance redundancy for each function.

A similar approach was taken in the development of the destruct system for the *ASSET* vehicle, by McDonnell Aircraft Corp., St. Louis, Mo., and Aerojet-General Corp., Downey, Calif. Two EBW detonators and two firing units are used for redundancy, a single liquid-explosive charge being placed in the vehicle.

- **PETN vs. other explosives**—Apart from questions of detonation theory and redundancy, other discussions centered on use of PETN versus other explosives and the importance of various parameters in bridge-wire design.

EBW systems with PETN explosive loading were used very successfully in the original Atomic Energy Commission devices. Adaption of EBW systems of this sort to missile systems has raised problems, however, chiefly because of the complexity of the missile system and the very high level of interfering RF sources. The EBW characteristic of submicrosecond firing precision has been of little importance in missiles.

In some programs, other explosive loadings such as RDX and HMX are preferred to PETN because of the better temperature and vacuum stability and their non-hygroscopic nature.

In experiments on EBW parameters, H. S. Leopold and I. Kabik of the U.S. Naval Ordnance Laboratory, White Oak, Md., found that increasing circuit inductance and resistance decreased the probability of detonating PETN.

- **What causes ignition?**—For fixed circuit parameters of capacitance, inductance, extraneous resistance and initial potential, they found that there was an optimum wire diameter for a fixed wire length, and an optimum wire length for a fixed wire diameter.

These results lead them to think that initiation is thermal in origin and that a minimum volume of PETN must be initiated for detonation to take place. This minimum volume is greater than that ignited by direct contact with a hot wire.

The fact that wires that exploded most vigorously in air were not the best for detonating PETN bore out the idea that the shock wave produced by the exploding wire was not the basic detonating mechanism. Calculations of shock pressure corroborate this, they said—it is two orders of magnitude below that needed to detonate PETN in explosive shock experiments.

Leopold and Kabik conclude that the experiments on wire length and diameter show that growth from burning to detonation is critical. Further initiation occurs from the hot wire plasma and vapor as they expand to fill the explosive interstices. Increased pressure from the wire vapor speeds the burning process and accelerates the liberation of chemical energy from PETN already ignited.

● **Detecting duds**—D. E. Davenport and M. A. Picciano of General Precision, Inc., Sunnyvale, Calif., pointed out that although knowledge of the mechanisms of initiation from an EBW is incomplete, empirical knowledge about the importance of explosive density and explosive contact with the surface of the wire gives a good lead toward methods of testing for potential duds.

They assume that a serious dudding problem results when enough current flows through the bridgewire to melt or decompose it or to alter a significant amount of material adjacent to the bridgewire. When the current does not melt the bridge wire, the EBW seems intact, but will not initiate an explosion.

Davenport and Picciano suggest that dudding will occur when the void around the bridgewire is big enough to degrade the expanding vapor and shock waves from the EBW, before they come into contact with the active explosive.

They suggest that a potential dud can be detected by measuring the radial heat transfer properties of the material around the bridgewire. This can be done by measuring the temperature rise when a small current passes through the wire. If the wire has a significant temperature coefficient of resistance, the temperature rise can be measured quite easily.

● **ASSET destruct system**—The *ASSET* program aims to obtain temperature and pressure data on hypervelocity lifting reentry vehicles to aid in the evaluation of advanced materials and systems.

Flight termination in *ASSET* is by a self-monitoring system, because of the difficulty of attaining reliable RF command transmission through the vehicle's plasma sheath.

Destruction may be initiated by a self-destruct sensor, a low-voltage sensor, by booster command, or by premature separation.

When destruct is ordered, a liquid explosive initiated by an EBW detonator cuts the wing-body structural attachments. This removes the aft portion of the left wing, causing a rolling ballistic trajectory.

Because skin surfaces on the *ASSET* are thermal radiating materials, they cannot be fitted with access doors for equipment installation or check. Instead, the main body cover is fitted to the vehicle before mating it to the booster.

But a prime requirement for the destruct system is that the explosive charge be put in as late as possible and be removed quickly after the vehicle reaches the recovery area.

To get around this dilemma a shaped charge of liquid explosive is used. The container for this includes fill and vent lines that are brought to the rear of the *ASSET* vehicle, where they are accessible. Filling and draining are carried out with a small hand-operated bulb-type pump.

Aerex liquid explosive, a product of Aerojet-General, is used. This is 95% by volume nitromethane and 5% sensitizer.

Because of the limited access to the vehicle, the initiator and safe-arm mechanism is installed before *ASSET* is moved to the pad. Safety was therefore a prime factor in selecting components for the system. An EBW detonator with RDX was chosen, because of its decreased sensitivity and better thermal stability than PETN.

The charge container for the Aerex explosive is a tubular aluminum section with a "shaped" region at each end, where an EBW detonator is located.

A flush-soldered bridgewire with a series spark gap is used. The spark gap prevents energy levels having a potential below 700 volts from passing through the bridge wire. Flush soldering was found to be more reliable than other configurations studied, such as raised soldered, and flush or raised welded. Three different densities of RDX are used in the explosive train.

Output of the electronic firing unit is 2 joules, in response to a trigger signal of between 18 and 32 volts. Solid-state components in welded modules, potted in epoxy, are packed within a hermetically-sealed metal case.

● **Pershing modular EBW system**—In early versions of the *Pershing* missile, the high-voltage firing unit for all ignition, termination, and separation functions was located in the guidance and control section. High-voltage energy was transmitted over long transmission lines to ordnance items in various parts of the missile.

Because the centralized system was likely to be unreliable under field conditions, modular firing units located close to each ordnance function were developed.

Fourteen ordnance functions are required: two each for first- and second-stage ignition, two each for first-stage and re-entry body separation, and two for each of the three motor ports for thrust termination.

To discriminate against voltages below 650 v, a spark gap is built into the ordnance electrical connector. A 0.5-microfarad capacitor was selected as sufficient to provide consistent explosion of the 1 to 2 mil diameter gold-alloy bridge wire. Output voltage of the firing unit is 2,250 v, yielding an energy of 1.27 joules.

The basic EBW initiator is used to initiate pyrotechnique motor igniters and to detonate splicebolts and motor thrust port segments. It consists of an electrical input connector and a 45-milligram explosive charge of PETN pressed to a density of 1 gm per sq. cm.

A motor igniter converts the high-order detonation from the EBW initiator into a pyrotechnic output, by use of a 135-milligram pressed boron potassium nitrate pellet. This ignites a pyrogen assembly that provides motor ignition. In the interstage bolt detonator, the output from the EBW initiator sets off a transfer column of mild detonating fuse that detonates a base charge of 160 milligrams of PETN. This shears a splice bolt, allowing stage separation.

The control portion of the firing unit consists of a silicon controlled-rectifier that discharges a trigger capacitor through the primary of a pulse transformer to provide the high-voltage pulse required by the switching electrode of a gap tube. The SCR is biased so that the application of two discrete signals is required before triggering takes place.

● **Polaris EBW detonators**—The squibs and detonators developed by Lockheed for *Polaris* are coaxial types with a steel body encasing a ceramic liner. Two Kovar pins inserted into a center piece of ceramic form a spark gap assembly. One of the end pins is used as the electrical contact element for the connector and the other end forms one of the bridge-wire terminals.

The bridgewire is connected between the gap assembly and a nickel cup brazed on the ceramic liner. All parts of the unit are assembled by brazing, except the bridge wire, which is welded in place.

● **Spark gaps vulnerable to EMP**—The vulnerability to electromagnetic radiation of a spark gap in series with the exploding bridge wire was stressed by D. E. Seeger, Picatinny Arsenal, Dover, N.J. Use of such a gap could render a system more vulnerable to electromagnetic radiation than a system with no gap.

If an EBW device with a gap is subjected to an electromagnetic field of sufficient intensity to break down the gap, the impedance match of the initiator system will change drastically. It will go from some high level to a lower level characteristic of the bridgewire, probably passing through a perfectly-matched condition with the transmission line and external leads that serve as an antenna.

At this point, maximum transfer of energy from the electromagnetic field to the bridgewire is achieved. By comparison, the system with no gap already has a large impedance mismatch. ■

Lockheed Propulsion Company static fires free world's first 10-ft. diameter segmented solid propellant rocket motor. Standard Steel supplied forged and machined rings for the motor casing.

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In 1964, the first 156-in. diameter large solid rocket motor will be static fired in California. Rings forged and machined from a remarkable new material—18% Nickel Maraging Steel—will hold together the segments of the motor casing. Standard Steel, a leader in the development and exploration of this tough, distortion-free alloy, produced the rings for Lockheed Propulsion Company. Talk to Standard about what maraging steels can do for your application.

First successful rolling of a 156-in. diameter ring of 18% Nickel Maraging Steel was recently completed at Standard Steel. Standard has also supplied to industry conditioned ingots and blooms for a missile dome test project and preforms for a rocket motor case evaluation program.

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Bendix Simulating Lunar Magma in Laboratory Tests

by John F. Judge

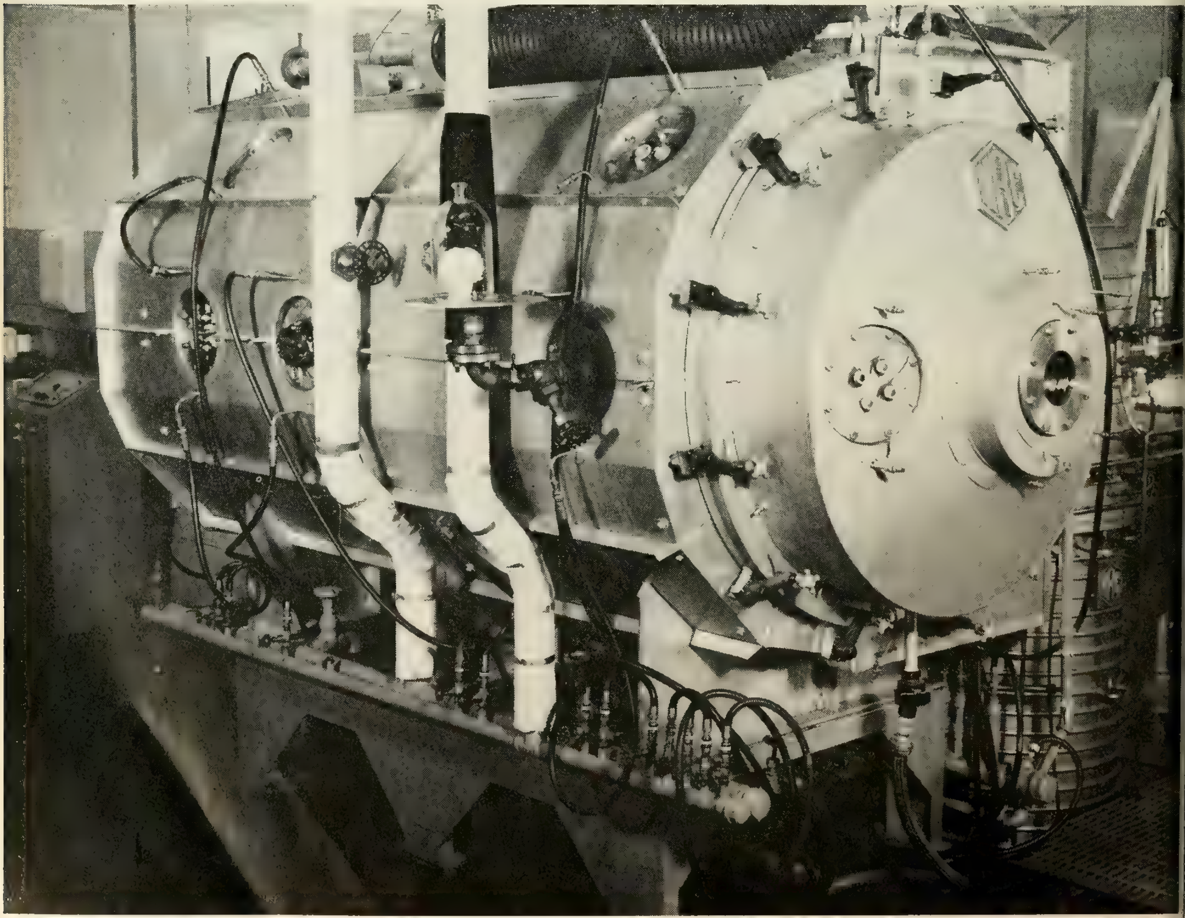
ANN ARBOR, MICH.—If magma expanded or "upwelled" through the lunar surface, then it might be possible to simulate the process with common geological materials.

Such an approach is under way at the Bendix Corp.'s Systems Div. Research Labs with an eye toward laying the groundwork for future correlations between lunar surface materials and those on the earth.

Scientists at Bendix have expanded molten rock in a vacuum and found that some of the experimental data fit in with published lunar information.

Bendix is being extremely careful in its experimental approach to the lunar surface composition area since there is little hard information available and the subject is highly speculative.

The company-funded magma ex-



pansion work at Bendix is one facet of the firm's interest in the lunar environment. Bendix is interested in post-*Apollo* space business, and the investigations into simulating the lunar surface are one way of establishing a broad base for future hardware concepts.

Samples of expanded rock are being subjected to tests in five general areas—thermal, albedo, light scattering, light polarization and colormetric analysis. The work in lava upwelling into vacuums is being conducted by Walter I. Dobar, Manager, Quality Assurance Dept., a graduate geologist, continuing his studies in Astro-geology at Michigan State University.

The equipment and instrumentation used by Dobar in gathering data from his specimens and other samples of geological materials is unique in that they are primarily aimed at weapons systems evaluations. Thus the instrumentation at the lab is completely calibrated against primary and secondary NBS standards.

Dobar feels that few, if any, previous investigators into lunar surface materials simulation had this capability at their disposal. His results in the initial series of measurements, especially thermal and albedo, show remarkable agreement with observed values published by various lunar authorities.

Dobar is seeking a single geological type with all of the observed properties of the lunar surface—after the sample has been allowed to upwell into a vacuum.

Should this prove possible, a strong base for the future correlation of lunar surface data will exist, and substantial progress can be made with a minimum of "hard" data from the currently programmed probes—manned and unmanned.

- **Test procedure**—A 50-mm-by-volume sample of flint glass or Wausau sand is placed in a 100-mm crucible. The silicon dioxide sample is then melted in a muffle furnace at a temperature of 1,500°F. The sample is held in the molten state at temperature for 15 minutes to permit a gaseous/liquid equilibrium state to develop—representative of the dissolved gas pressure found in natural magma.

The molten sample is quickly moved to a bell-jar base plate built into the side of a 4 x 8-ft. vacuum chamber capable of reaching 10^{-8} torr. The 6-in. bell jar is placed over the sample and the sample area is evacuated into the larger vacuum system.

The molten sample cools and "upwells" during the rapid decompression of the bell jar—simulating a typical geological process of magma upwelling on the surface of the Moon into a hard vacuum.

- **Interesting results**—Visual and high-speed color motion pictures show that during the decompression-transformation period, the sample radiates a high intensity orange to red light that sparkles. The complete color phenomena is in good agreement with that observed by members of Lowell Observatory of "red spots" on the moon in October and November, 1963.

In both sample areas, the result is a frothy silica mass, 15 to 20 times the volume of the original molten mass. Dobar calls the samples "Simolivac"—silica molten in vacuum. The outside surface structure of the expanded Wausau samples has a rough, porous texture while the internal structure consists of a large number of interconnected voids. The webbing forming the interconnecting walls was opaque and the microstructure showed small spines or whiskers covering almost the entire web area.

The outward surface structure of the flint glass froth has a relatively smooth fibrous texture with a limited porous microstructure. The internal structure is very similar to that of the Wausau sand result.

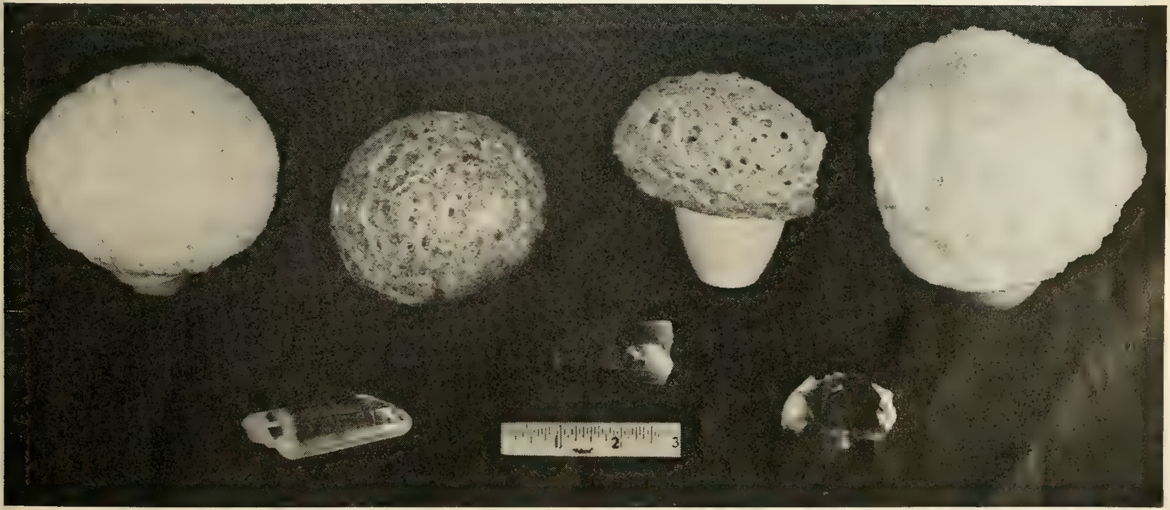
Bearing (unconfined compression) strength was determined by John P. Gnaedinger of Soil Testing Service, Inc., and showed that Wausau "Simolivac" can support 4 tons per sq. ft.

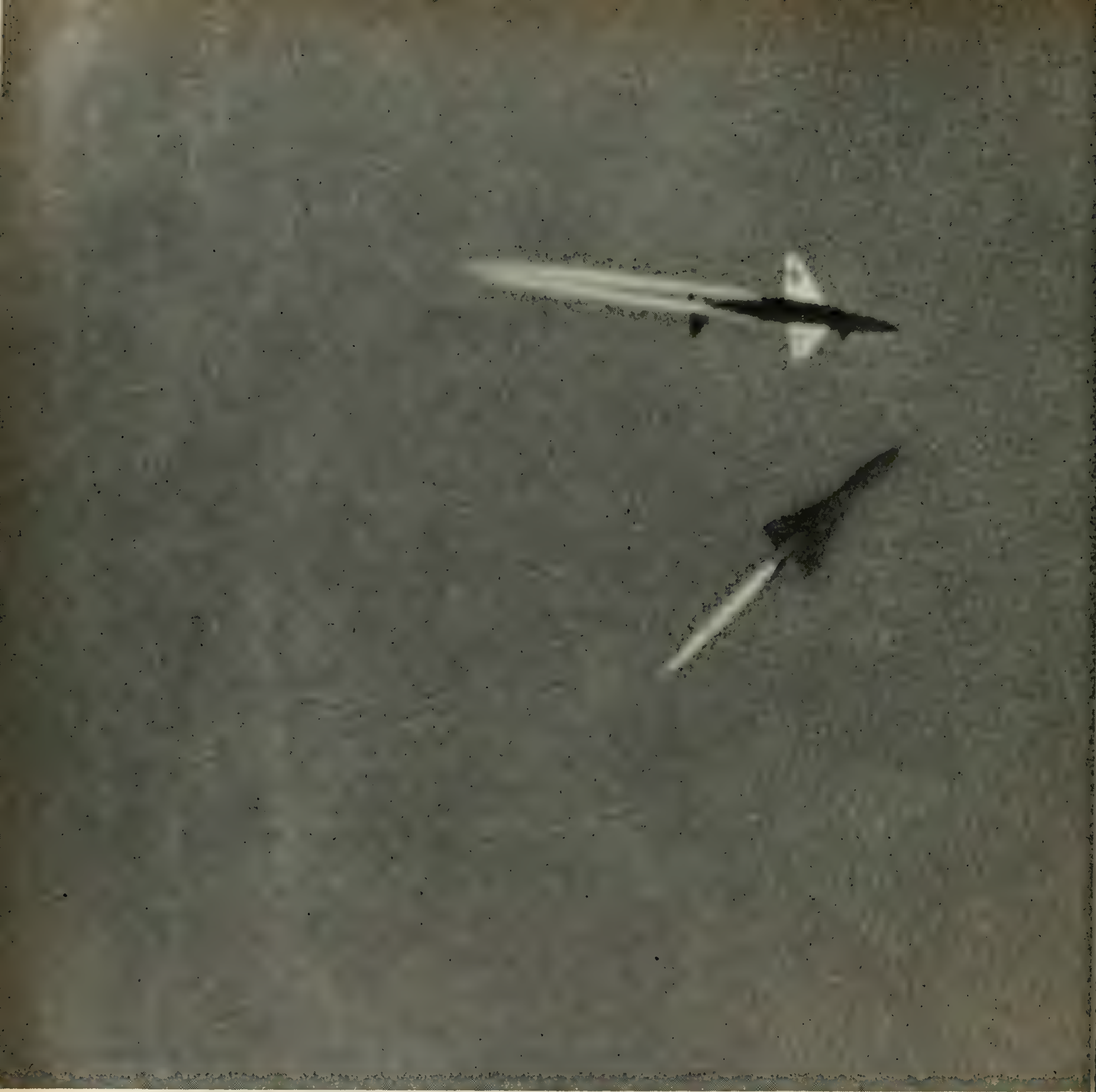
The microstructure in the expanded Wausau sand is very similar to that found in certain varieties of non-geological samples such as cellulose sponge and lichen, which give reflection curves with excellent correlation with the Moon's surface.

Samples of vacuum-expanded flint glass, Wausau sand and clear quartz crystal were subjected to gamma radiation for 94 hours by Dobar. This preliminary experiment was conducted to determine the effect, if any, of the radiation on the photometric properties of SiO_2 material.

The radiation damage—observed visually and photometrically—was similar for all three samples. The discoloration of the quartz crystal was not as dark as in a piece of natural smokey quartz. But the discoloration of all three samples bears a remarkable resemblance to that of a thin section of a tektite, says Dobar. ■

LEFT: Molten sample is placed in bell jar platform attached to a large vacuum chamber. BELOW: Left to right are clear expanded quartz, used a control; irradiated expanded clear quartz; expanded natural smoky quartz and an expanded clear quartz. Original samples of flint glass and smoky quartz are in foreground.





The Hawk has been hunting the RP-76 since June, 1960.

Northrop's RP-76 target drone provides the most effective exercise for the Hawk missile short of combat. It performs at high or low altitudes.

To a Hawk, the RP-76 looks, flies and maneuvers like an enemy plane. Yet, unlike most realistic targets, it can be destroyed without prohibitive cost. It has the lowest cost per mission of any missile target system.

The RP-76 has flown over 2000 missions against Nike, Hawk, Sparrow, and Sidewinder, with a reliability rate of 87.5%. Northrop has provided complete RP-76 target services – flight operations, launching, control, tracking, scoring, repair and maintenance – for U.S. and Nato forces in the United States, the Pacific and the Far East.

The RP-76 is the world's most experienced target for high-performance missiles. It is a natural prey for the Hawk.

NORTHROP RP-76

Mergers and Acquisitions

Eithel-McCullough, Inc., San Carlos, Calif., has purchased from Capitol Records, Inc., the pulsed traveling wave tube portion of Capitol's business. The TWT was developed by the EMI Div. of Capitol and marketed by its subsidiary, ElectraMegadyne, Inc. Included in the transaction were all design laboratory and manufacturing facilities of Capitol's pulsed TWT operation, along with the lease of a 20,000-sq.-ft. plant in Los Angeles. . . . *Andersen Laboratories, Inc., West Hartford, Conn., has acquired from the General Electric Co. a license relating to sonic delay lines. The agreement licenses technical information pertaining to magnetostrictive, piezoelectric and dispersive delay lines, and also transfers to Andersen certain manufacturing tooling.*

New Activities

Philco Corp.'s TechRep Div. is regrouping its operations and staff functions in accordance with a new business philosophy under which the division will operate in the future. The new organization will include four business activities—TechRep Operations, Documentation Operations, Training and Training Aids Operations and Systems Support Operations. They will be supported by five staff offices—marketing, controller, engineering, operations planning and development, and industrial relations. . . . *Sunbeam Electronics, Inc., a new subsidiary of the Sunbeam Corp., has broken ground in Ft. Lauderdale, Fla., for a new 150,000-sq.-ft. manufacturing and research and development facility. The new firm replaces the Avionics Div. of the John Oster Manufacturing Co., Racine, Wisc. Sunbeam is planning to increase its contribution to the market for precision rotating products for missiles, spacecraft and aircraft.*

AIA Urges Shipping Cost Cuts

The Aerospace Industries Assoc. has begun distribution of questionnaires to traffic managers of major missile/space concerns in an effort to pinpoint the industry's shipping problems and to develop less expensive ways to ship raw materials, parts and finished hardware. The survey is a result of a September meeting between AIA and the Dept. of Defense. When the questionnaires are completed, the answers will be analyzed for clues on cost-reduction possibilities.

NASA Grants 28 Patent Waivers

NASA has granted to twelve companies, a university, a research organization and two individuals 28 patent waivers to inventions arising from NASA-contracted research. The action brings to 74 the total number of waivers granted by the space agency. NASA retains a royalty-free license for any Government use of the inventions, and may void the waivers after five years if the recipients do not show further development on the inventions to the point of practical application or have not made them available for license by others.

International

Hawker Siddeley Dynamics, Hatfield, Herts, England, has signed an agreement with the French rocket company, Engins Matra, for cooperation on all aspects of research, development and production in the electronics and missile/space research fields. Previous collaboration has been on the development of automatic test equipment. Hawker Siddeley Dynamics is responsible for the *Blue Streak* rocket, which will form the basis of the European Launcher Development Organization's (ELDO) program for a three-stage satellite launching vehicle. . . . *Optics Technology, Inc., Belmont, Calif., has announced formal affiliation with the Belgian optical firm, Societe Belge d'Optique et d'Instruments de Precision, Ghent, Belgium. Covered by the agreement would be cooperation on such points as: joint research and development, exchange of technical information and personnel, cross-licensing of patents and products, cross-licensing of marketing rights, and cross licensing of manufacturing processes and techniques.* . . . American Air Filter Co., Louisville, Ky., is scheduled to open in the near future its first glass fiber manufacturing operation in Europe. AAF Nederland n.v. will be operated as a wholly-owned subsidiary in Amsterdam and will manufacture the company's line of Roll-O-Matic filters.

New Facilites

Ling-Temco-Vought's Astronautics Div. is installing a new propulsion test facility near its Grand Prairie, Tex., plant. The new facility will be used in the design, development and test of propulsion and control systems in support of company projects. The company does not plan to enter the fields of propellant or rocket motor manufacture. . . . *Aaron Power Sources has opened a new plant in Van Nuys, Calif., to specialize in manufacturing of converters and inverters. It will also produce dc-to-ac (DSA series) sine wave units.* . . . Bell-Metrics Corp., San Fernando, Calif., manufacturer of precision welded bellows for missile/space systems, has completed a new 13,000-sq.-ft. plant. A 1¼-acre site in the San Fernando Industrial Park affords room for future expansion to 30,000 sq. ft. . . . *Packard Bell Computer Div. of Packard Bell Electronics has completed a move into a new headquarters building in Santa Ana, Calif. More than 400 engineering, manufacturing, marketing and administrative personnel are now in the 75,000-sq.-ft., $1-million facility, which consolidates serveral operations formerly housed in separate locations.* . . . Malaker Laboratories, Inc., High Bridge, N.J., has opened company offices in Washington, D.C. ML designs and manufactures cryogenics equipment for commercial and military applications.

AWARDS

AIR FORCE

$4,400,000—**Lockheed Missiles and Space Co.,** Sunnyvale, Calif., for continued research and development on an unnamed project with space applications.

$2,600,000—**Aerojet-General Corp.,** Azusa, Calif., for follow-on production of radiometric equipment.

$2,500,000—**Douglas Aircraft Co., Missiles and Space Systems Div.,** Tulsa, Okla., for space booster modifications and related GSE.

$2,300,000—**North American Aviation, Inc., Autonetics Div.,** Downey, Calif., for *Hound Dog* missile modifications, spares and related GSE.

$2,000,000—**Sperry Rand Corp., Univac Div.,** New York City, for integration of a data processing system into the Limited Warfare Intelligence Reduction Complex (LWIRC) at Rome, N.Y.

$650,000—**Packard Bell Electronics Corp., Space and Systems Div.,** Los Angeles, for modification and improvement to the Weather Information Network Display (WIND) Systems at Vandenberg AFB, Calif.

$250,000—**Sylvania Electric Products, Inc., Microwave Div.,** Williamsport, Pa., for production of magnetrons for military applications.

$196,879—**American Machine and Foundry Co.,** Alexandria, Va., for development of manufacturing methods for deposition forming of aerospace components.

$99,686—**Regents of the University of Michigan,** Ann Arbor, Mich., for solid-state microwave research.

$86,406—**Thompson Ramo Wooldridge, Inc., Electromechanical Div.,** Cleveland, for a feasibility demonstration of a transpiration-cooled rocket nozzle system.

$81,192—**Stanford Research Institute,** Menlo Park, Calif., for research in response to burning propellant surfaces to erosive transients.

$57,936—**Utah Research and Development Co., Inc.,** Salt Lake City, for research on hypervelocity particle impact effects.

$55,745—**General Electric Co., Missiles and Space Div.,** Philadelphia, for research on structural response to intense electromagnetic radiation.

$46,390—**General Dynamics Corp., General Atomics Div.,** San Diego, Calif., for non-linear theory of plasma dynamics.

ARMY

$5,000,000—**Ling-Temco-Vought, Inc.,** Greenville, Tex., for work on classified electronics equipment.

$2,000,000—**Union Carbide Corp.,** New York City, for research in physical and chemical principles affecting high temperature materials for rocket nozzles.

$322,690—**Raytheon Co.,** Andover, Mass., for *Hawk* missile system engineering services.

$295,945—**Tri-Central Construction Co.,** Fresno, Calif., for construction of a research and engineering administrative space building at Vandenberg AFB, Calif.

$182,600—**General Electric Co., Defense Electronics Div.,** Syracuse, N.Y., for HIPAR radar sets related to the *Nike* missile system program.

$70,000—**North American Aviation, Inc., Columbus Div.,** Ohio, for continuation of effort and increased estimated cost of the *Redhead Roadrunner* target missile system.

$55,854—**Hayes International Corp.,** Birmingham, Ala., for *Pershing* missile trainers.

$38,870—**ITT Gilfillan, Inc.,** Los Angeles, for cables for use in the *Corporal* missile.

$29,250—**Western Electric Co.,** New York City, for items related to the *Nike-Hercules* missile system.

$27,198—**Poly Industries, Inc.,** Pacoima, Calif., for *Little John* missile metal motor parts.

$26,613—**Martin Marietta Corp.,** Orlando, Fla., for modification kits for *Pershing* missiles.

$25,918—**Douglas Aircraft Co.,** Charlotte, N.C., for *Nike* missile system spare parts.

NAVY

$9,662,240—**Varo, Inc.,** Garland, Tex., for production of guided missile launchers.

$6,900,000—**Sperry Rand Corp., Univac Div.,** New York City, for 19 data processing systems related to work at NOTS, China Lake, Calif.; Naval Electronics Lab, San Diego, Calif., and various PMR sites.

$5,900,000—**ITT Federal Labs,** Nutley, N.J., for development and production of atmospheric and underwater tracking systems.

$4,700,000—**Lear Siegler, Inc.,** Grand Rapids, Mich., for production of computer systems.

$2,300,000—**University of Washington, Applied Physics Laboratory,** Seattle, for research and development related to underwater weapons and associated equipment.

$842,000—**Western Electric Co.,** Winston-Salem, N.C., for design change for *Terrier/Tartar* weapons system direction equipment.

$680,000—**Hycon Manufacturing Co.,** Monrovia, Calif., for repair, rework and alteration of all models of *Terrier/Tartar* missile test sets and related equipment.

$137,000—**Martin Marietta Corp.,** Orlando, Fla., for production of miscellaneous parts related to the NATO *Bullpup* missile production program.

$116,740—**Zero Manufacturing Co.,** Silver Spring, Md., for production of missile containers.

$96,436—**Vitro Corp. of America, Vitro Laboratories Div.,** Silver Spring, Md., for a study contract for research and development in the field of weapons systems installations for air-launched and ship-launched weapons systems, including a study of associated ground support equipment for shipboard and land-based facilities.

$72,316—**Sperry Rand Corp., Sperry Gyroscope Co.,** Syosset, N.Y., for definition of the navigation and guidance requirements for advanced weapons concepts being considered for the Advanced Sea-based Deterrent System.

$49,000—**Raytheon Co.,** Waltham, Mass., for technical publications related to aerospace ground equipment.

NASA

$789,970—**Pearce & Gresham Co.,** for construction of a *Saturn V* booster instrument testing facility at the Marshall Space Flight Center.

$396,430—**Advanced Technology Laboratories,** Mountain View, Calif., for a *Pioneer* spacecraft micrometeoroid detector experiment.

$160,000—**Philco Corp., Tech Rep Div.,** Philadelphia, for monitors for spacecraft systems.

$92,300—**Operations Research, Inc.,** Silver Spring, Md., for independent reliability studies of the *AOSO*.

$45,000—**Fairchild Stratos Corp.,** Bayshore, N.Y., for field engineering services for an APT ground station (Tiros).

$38,000—**Joseph Kaye & Co., Inc.,** Cambridge, Mass., for construction of 24 special thermocouple reference systems for use in the test and evaluation of space satellites undergoing dynamic testing prior to launch.

ARPA

$1,200,000—**General Motors Corp.,** Goleta, Calif., for continuation of study on space re-entry vehicles.

DEFENSE COMMUNICATIONS AGENCY

$3,400,000—**Western Union Telegraph Co.,** for installing digital communications equipment at Larsen AFB, Wash., and Hancock Field, Syracuse, N.Y.

MISCELLANEOUS

$2,200,000—**Air Products & Chemicals, Inc.,** Allentown, Pa., from the **Boeing Co.,** for *Saturn S-1C* gaseous nitrogen system.

$1,600,000—**Trans-Sonics, Inc.,** Lexington, Mass., from the **Boeing Co.,** for liquid leveling system related to *Saturn*.

$1,300,000—**Hughes Aircraft Co.,** Fullerton, Calif., from the **French Navy,** for manufacture of a naval tactical data system display subsystem.

$1,000,000—**Beckman Instruments, Inc.,** Fullerton, Calif., from **Grumman Aircraft Engineering Corp.,** for a data acquisiton system to be used in development and test of the Lunar Excursion Module (LEM) of NASA's Project *Apollo* program.

$800,000—**Bendix Corp., Pioneer-Central Div.,** Davenport, Iowa, from the **Boeing Co.,** for production of a LOX and fuel loading system for ground monitoring and "topping off" procedures.

$221,000—**Fred D. Wright Co.,** Nashville, Tenn., from the **Boeing Co.,** for *Saturn S-1C* LOX ducting system.

$113,000—**D.K. Manufacturing Co.,** Chicago, Ill., from the **Boeing Co.,** for development of a water deluge system.

Electro-Optical Systems, Pasadena, Calif., from **Jet Propulsion Laboratory,** for fabrication of 11 solar panels for the *Mariner-Mars* space vehicle (undisclosed amount).

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Procurement and Production Directorate
ATAC
Michigan Missile Plant
Warren, Mich.

Evaluate the swirl stratified charge combustion system installed on the military model L-141 engine. No. EH-4-1R789-01-EH-AH. Proposals will be solicited from the Southwest Research Institute, 8500 Culebra Road, San Antonio 6, Tex. Detailed specs suitable for solicitation of bids are not available. Contractual action to be finalized by 5-11-64. It is suggested that small business firms and others interested in subcontracting opportunities make direct contact with Southwest Research Institute.

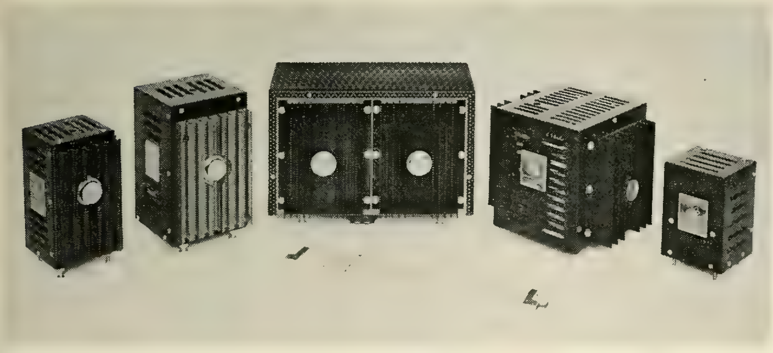
The Army Tank Automotive Center has authorized the Philadelphia Procurement District, U.S. Army, to process an allocation for the procurement of research and development services as follows: develop and fabricate a breadboard model of an active defense mechanism. No. M1-4-9R126-01-EH-AD. Proposals will be solicited only from Philco Corp., Communications and Electronics Div., Blue Bell, Pa. Detailed specs suitable for solicitation of bids are not available. Contractual action to be finalized by 5-12-64. It is suggested that small business firms and others interested in subcontracting opportunities make direct contact with Philco Corp.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Ala.

Apollo logistics support systems payload. Period of performance shall be 12 months from date of any resultant contract—nine months for completion of work plus three months for preparation and submission of technical summary report. RFQ 1-4-21-01015-01 will be available on a first come, first served basis. Attn: J.M. Stuart Phone: 536-0731.

Titan Procurement Division
Guidance Branch
Norton AFB, Calif.

This synopsis is being submitted for subcontracting opportunities. Manufacturing drawings and specs are not available through Air Force channels. Procurement will be made for recorders, digital to analog, P/N GS-63938A, FSN 14300204591AE in support of the HGM-25A Titan missile—2 each. RFP 04-607-64-1078. Negotiations for these items are being conducted with Western Electric Co., Inc., Burlington Shops, Burlington, N.C. Small business firms and others interested in subcontracting opportunites should make direct contact with Western Electric Co.



New Product of the Week: X-Ray Unit

An "instant X-ray" unit that provides radiographic inspection of small components in 10 sec. without an X-ray room or darkroom is being marketed by Field Emission Corp.

The Model 803 weighs 100 lbs. and includes a lead-lined chamber measuring 10½x10½x12½ in. for radiation protection. The X-ray tube can be rotated 90 degrees to extract the X-ray beam for external use on larger objects outside the chamber. Low-current energy from a 110-v source is discharged in 100 or 150-kv X-ray bursts of short duration (0.05 microsec.). The small X-ray source size of 1.8 mm. gives maximum resolution at the center of the film and proportionally uniform resolution elsewhere. A 2% penetrameter insures detection of correspondingly small percentage changes in density and thickness with such typical object thicknesses as ⅛-in steel or ½-in aluminum.

Circle No. 151 on Subscriber Service Card

Coaxial Mixer Diodes

Microwave Associates, Inc., has developed a line of coaxial mixer diodes for broadband microwave applications in the 12 to 18-gc frequency range.

The MA-490 series of silicon point-contact diodes were primarily designed for Ku-band mixer applications. Maximum over-all noise figures are as low as 8.0 db measured at 16 gc. Mixer noise figure of 7.5 db is typical. The units will meet MIL-S-19500C specifications. Temperature rating is 150°C. Burnout is rated at 1 erg; maximum conversion loss is 6 db and maximum VSWR is 1.5 at 16 gc. IF impedance is 400 to 565 ohms; maximum noise ratio is 1.9.

Circle No. 152 on Subscriber Service Card

Phase/Amplitude Test Set

A heterodyne phase and amplitude test set for the fields of satellite relay communications, FM relay, phase array radars and other systems is being marketed by Wiltron Co.

The instrument covers the 2.5 to 400-mc range with full electronic operation. The electronic operation is achieved by an electronically variable delay line which makes a phase correction in one arm of the phase bridge to equalize the phase of the two signals being compared. Amount of correction is directly proportional to the relative phase between signals.

Measurements are possible over the full 360-degree range with no quadrant determination required. Resolution is 0.1 degree at any angle. Simultaneous amplitude measurements are made on both input signals over a 90-db range, 60 db of which is read out on a linear scale meter.

Circle No. 153 on Subscriber Service Card

Amplifier Klystron

A five-cavity amplifier klystron designed for troposcatter communications applications is being introduced by Eitel-McCullough, Inc.

The Model 5K50CB produces 10 kw CW at C-band. The tube operates at 4.4 to 5.0 gc with a minimum gain of 53 db. The cooling system will accept ethylene glycol and water to provide additional system flexibility.

Circle No. 154 on Subscriber Service Card

Signal Generator

Marconi Instruments is marketing the Model 2002 transistorized standard signal generator, covering a 10-kc to 72-mc frequency range in eight bands.

The solid-state unit reaches full stability after five minutes warm-up; any remaining drift is covered by the specification of 100 pts per million per degree C±5 cps/°C. A crystal calibrator gives check points at 1 mc, 100 kc and 1 kc.

Modulation facilities include AM up to 100% either external or internal from an oscillator continuously tunable from 20 cps to 20 kc. FM on AM is less than 1x10^{-8} of carrier frequency at 100% modulation.

Circle No. 155 on Subscriber Service Card

Micaceram 1802

A machineable high-temperature material, Micaceram 1802, is being offered by Molecular Dielectrics, Inc.

The material maintains dimensional stability properties after extended periods in temperatures up to 1,800°F. At 1,600°F for a four-hour period, less than 0.0002 growth was measured. At 1,800°F, growth was less than 0.0005.

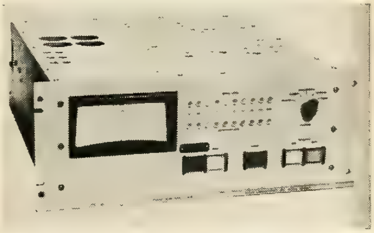
Dielectric properties include a dissipation factor of 0.0036; dielectric constant of 6.3; loss factor of 0.025, and a flexural strength of 8,000 psi.

Circle No. 156 on Subscriber Service Card

Phase/Voltmeter

A programmable phase/voltmeter for use with digital voltmeters to provide automatic or manual control in measuring in-phase and quadrature voltages is being marketed by Acton Laboratories, Inc.

The Model 365-A measures fundamental signal levels, in phase and quadrature voltage components to accuracies of ±0.15% and phase angles to ±0.1 degrees. It can be stepped manually or automatically among these parameters in any required sequence.



The device features automatic ranging in 10 scales from 0.01 to 300v. Reference voltage is measured in the same ranges. Output to digital instruments ranges to 3v dc in the voltage measuring mode and to 3.6v dc in the phase measuring mode. Standard frequencies are 800 and 4,800 cps. Impedance input and output resistance is 10 K ohms.

Circle No. 157 on Subscriber Service Card

Cathode-Ray Tube

A radial resolution cathode-ray, tube, the Model CK1378, has been developed by Raytheon Co.'s Industrial Components Div.

The unit can be used as a multiplexer for coded transmission, a frequency multiplier from 60 cps to 30 kc and an analog-to-digital converter. In its present configuration, the tube can separate signals into 10-degree sectors.

From a single cathode ray gun at the input end of the tube, an electron beam is projected to the target end where the 3-in.-dia. target face is precision-etched into 36 equal and electrically isolated sectors. Each sector is connected to a separate output lead terminating in one of the external bases.

Circle No. 158 on Subscriber Service Card

Wideband Amplifier

Philbrick Researches, Inc., has developed the Model SP456 wideband operational amplifier, designed to be stable over a wide range of feedback ratios.

The plug-in, chopper-stabilized unit has an open loop gain of 10^8 at dc, 100 at 1 mc. Offset drift is 1 mv per day; output is ±10v at 20 milliamp. With electromechanical chopper, maximum voltage offset is less than 50 mv referred to the input at temperatures from −25° to 85°C. Flicker noise is less than 10 mv peak-to-peak, and 50 to 90 cps chopper-frequency noise is of the same order. Input impedance is greater than 400 K at dc and 100 K midband.

Circle No. 159 on Subscriber Service Card

Sweep Oscillator

A series of sweep oscillators available in seven basic models covering 1 to 40 gc is being marketed by Alfred Electronics.

The 640 series sweepers feature internal or external leveling, retrace blanking at all speeds for scope or recorder operation and accurate manual sweep. The solid-state units operate on 50 to 400-cps power.

Specifications include a frequency stability of better than 0.01% per degree C; broadband sweeps, 2 to 100% full range; a sweep time of 10 msec to 100 sec., and amplitude modulation internal 800 to 1,200 cps square wave.

Circle No. 160 on Subscriber Service Card

Wideband Wattmeter

F. W. Bell, Inc., is marketing the model HPM-501 wideband wattmeter, designed to measure electrical power over a 40 to 50,000-cps frequency range.

The unit provides direct measurement of real power in four ranges from 100 to 3,000 watts full scale over two frequency ranges. The influence on measurement with a leading or lagging power factor of 1 to 0.1 is less than 1%. Calibrated voltage at the output jacks has a dc component proportional to the real power and an ac component proportional to the volt-ampere product.

Circle No. 161 on Subscriber Service Card

TWT Transmitter

Energy Systems, Inc., has developed a solid-state/TWT telemetry transmitter capable of delivering 20 watts of power at S-band while operating under stringent environmental conditions.

The 2,200 to 2,300-mc unit has a modulation bandwidth from dc to 500 kc with peak deviation up to ±500 kc. Frequency stability is ±0.005%; distortion is 1.0% at 125-kc deviation.

The transmitter meets altitude requirements of free-space vacuum, −20° to 85°C, 20 g's vibration, 15 g's acceleration and 50 g's shock.

Circle No. 162 on Subscriber Service Card

Resistance Bridge

An automatic precision resistance limit bridge which performs dual-limit go/no-go resistance tests over a wide range has been announced by Boonton Electronics Corp.

The Model 100 tests over a resistance range from 1 ohm to 100 megohms with resolutions as low as 0.1 ohm. Tolerance range is continuously adjustable from 0 to ±30%; excitation voltage is variable from 0 to 100v dc. The unit can make up to 36,000 decisions per hour. It may be used with a test jig for manual loading or with optional Control Unit.

Circle No. 163 on Subscriber Service Card

1,500-Joule Laser

Maser Optics, Inc., is marketing the Model 4500 ruby laser with a rated energy output of 1,500 joules.

When used with Q-switching equipment, the device has a power output capability in excess of 100 megawatts. Maximum rated input energy is 120,000 joules at 3 kv. Pumping pulse is rated at 2.7 ms. The liquid nitrogen cooling system is automatically fed and controlled.

Circle No. 164 on Subscriber Service Card

Delay Line

Kappa Networks, Inc., is marketing a line of sub-miniature continuously variable delay lines.

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600 ohms. Rise time is 5 to 15 nanosec.; dielectric strength is 300v. The units have a resolution of better than 0.5 nanosec. and attenuation of less than 0.5 db. Operating temperature range is −55° to 125°C.

Circle No. 165 on Subscriber Service Card

Temperature Test System

Non-Linear Systems, Inc., has developed the Model 24302 circuit and component temperature test system.

The device can make electrical measurements on up to 100 electronic and electrical components or circuits at controlled temperatures. Operating temperature range is −200° to 600° F with a precision to ±0.1° F. Electrical ranges are 10 milliohms to 1 megohm and 100 μv to 1,000v dc. Accuracy is ±0.02% of full scale; speed is one sec./measurement.

Circle No. 166 on Subscriber Service Card

Pulse Amplifier

A modular pulse amplifier for operation at 100 mc repetition rates has been developed by Chronetics, Inc.

Designated the Model 106 Dual Nanoamp, the unit comprises two identical amplifier sections. Each is electrically independent and completely isolated from the other. Both accept input pulses at synchronous rates up to 100 megapulses/sec. Sensitivity is 1 mv into 50 ohms; input range is 1 to 50 mv, protected to 2v.

The model has a linearity of ±1% over a range of 1 to 40 mv. Gain is 10 ±1% adjustable. Power requirements are ±10v dc.

Circle No. 167 on Subscriber Service Card

Tension Compensator

Compensating Tension Controls, Inc., is marketing an unwind tension compensator for tapewinding of rocket motor nozzles and ablative hardware.

The unit can handle a roll of tape up to 40 in. in diameter and in various widths. Tension rates are available up to 25 lbs. output. Tension is infinitely adjustable within each range and is controlled to ±3% of the tension setting from full to empty roll of tape.

Circle No. 168 on Subscriber Service Card

RF Measuring Set

An advanced radio-frequency interference measuring set, the Model EMC-10, for use in the 20-cps to 50-kc frequency range, is being introduced by Electro-Metrics Corp.

The solid-state instrument features all-electronic tuning making possible automatic scan without mechanical drive, thus fulfilling MIL-STD-826 requirements.

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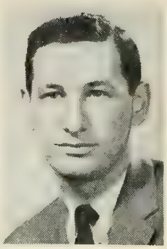

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Sidney Dennis: Appointed assistant general manager of AMF Atomics division of American Machine & Foundry Co.'s Advanced Products Group, Greenwich, Conn.

William F. Hafstrom: Appointed vice president of commercial development at North American Aviation's Autonetics Div., Anaheim, Calif.

Robert W. Seavey: Joined Cryonetics Corp., Burlington, Mass., as manager of engineering.

Stanley C. Mentzer: Appointed division manager of the R-F and Antenna Systems Div. of Dynatronics, Inc., Orlando, Fla.

Frederick J. Franco, Jr.: Joined Electro-Optical Systems, Inc., Pasadena, Calif., as assistant marketing manager.

Henry Kurland: Appointed manager of internal auditing at Fairchild Camera and Instrument Corp, Syosset, N.Y.

Robert W. Knight: Appointed director of quality control of ITT General Controls, Inc., Glendale, Calif.

Frank H. Bower: Joined Raytheon Co.'s Semiconductor Div., Mountain View, Calif., as manager of microelectronic manufacturing.

M. L. Van Doren: Appointed vice president of Electro-Mechanical Research, Inc., Sarasota, Fla.

Dr. Peter Van Wyck: Appointed assistant director of research for Hercules Powder Co.'s Research Center, Wilmington, Del.

John C. Sprague: Appointed executive vice president of Acheson Industries, Inc., Port Huron, Mich.

John R. Britt: Named district manager of the Detroit sales district of B. F. Goodrich Aerospace and Defense Products division of the B. F. Goodrich Co.

James H. Redman: Named manager of military requirements for data products at General Dynamics/Electronics, San Diego, Calif.

Dr. James Nicol: Elected vice president-research for Cryonetics Corp., Burlington, Mass.

D. George Davis: Named manager of Air Force programs for C-E-I-R, Inc., Arlington, Va.

Julian H. Ray: Elected president and chief executive officer of Washington Technological Associates, Inc., Rockville, Md. **Dermot Nee** named chairman of the board.

Don R. Hunter: Appointed general sales manager at Hughes Dynamics, Inc., Los Angeles.

Hasan Ozbekhan: Appointed director of planning at System Development Corp., Santa Monica, Calif.

Donn L. Williams: Elected president and chief executive officer of Tamar Electronics Industries, Inc., Anaheim, Calif.

George N. Krassner: Named manager, advanced communication systems for the Marketing Div. of Simmonds Precision Products, Inc., Tarrytown, N.Y.

Dr. Maurice Nelles: Appointed manager of manufacturing research and development at Westinghouse Defense and Space Center, Pittsburgh.

Gordon R. Justus: Named chief of systems research for the Systems Div. of Beckman Instruments, Inc., Fullerton, Calif.

Theodore J. Barringer: Named manager, industrial engineering, for Lear Siegler, Inc.'s Power Equipment Div., Cleveland.

Jules Lehmann: Joined Electro-Optical Systems, Inc., Pasadena, Calif., as manager of the newly formed Payloads and Imaging Systems Group.

Robert J. Weismann: Named vice president-general manager of Ampex Corp.'s Video and Instrumentation Div., Redwood City, Calif.

Alfred Kildow: Named manager of Aerojet-General Corp's New York public relations office.

when and where

MARCH

IEEE International Convention, Hilton Hotel and Coliseum, New York City, Mar. 23-26.

Technical Symposium, sponsored by Polytechnic Institute of Brooklyn, IRE, AIEE, Army, Navy and Air Force, New York City, Mar. 23-Apr. 2.

American Meteorological Society National Conference on Physics and Dynamics of Clouds, University of Chicago, Mar. 24-26.

Southwest Research Institute Aerospace Bearing Conference, San Antonio, Tex., Mar. 25-27.

American Society for Testing and Materials, Pyrolytic Graphite Symposium, Palm Springs, Calif., Mar. 30-Apr. 1.

APRIL

Society of Plastics Engineers, Engineering with Thermoplastics, Sheraton Hotel, Akron, Ohio, Apr. 1.

Worcester Polytechnic Institute, Annual Scientific Briefing for Tomorrow, Worcester, Mass., Apr. 1.

Optical Society of America Spring Meeting, Sheraton Park Hotel, Washington, D.C., Apr. 1-3.

AIAA Annual Structures and Materials Conference, Riviera Hotel, Palm Springs, Calif., Apr. 1-3.

American Chemical Society National Meeting, Philadelphia, Apr. 5-10.

22nd Annual Meeting, National Aerospace Services Association, International Inn., Washington, D.C., Apr. 6-7.

IEEE Rubber and Plastics Industry Conference, Sheraton-Mayflower Hotel, Akron, Ohio, Apr. 6-7.

Solar Energy Symposium, University of Florida, Gainesville, Apr. 6-7.

Pricing and Negotiating Prime and Subcontracts in the Defense and Aerospace Industries Seminar, sponsored by the Contract Management Institute, Palmer House, Chicago, Apr. 6-10.

IEEE International Conference on Nonlinear Magnetics, Shoreham Hotel, Washington, D.C., April 6-8.

ASME Design Engineering Conference and Show, McCormick Place, Chicago, Apr. 6-9.

ISA Measurement and Control Instrumentation Div. Symposium, Floridian Hotel, Tampa, Apr. 8-10.

48th Annual Meeting, Federation of American Societies for Experimental Biology, Conrad Hilton Hotel, Chicago, Apr. 12-18.

IEEE Symposium on Microelectronics, Chase-Park Plaza Hotel, St. Louis, Apr. 13-15.

Institute of Environmental Sciences, Annual Technical Meeting and Equipment Exposition, Sheraton Hotel, Philadelphia, Apr. 13-15.

American Power Conference, sponsored by IEEE and Illinois Institute of Technology, Sherman Hotel, Chicago, Apr. 14-16.

IEEE and ASME International Conference and Exhibit on Aerospace Electro-Technology, Westward-Ho Hotel, Phoenix, Ariz., Apr. 19-25.

ASTME Annual Meeting, Convention and Exposition, Detroit, Apr. 20-24.

Canaveral Space Congress, sponsored by Canaveral Council of Technical Societies, Ramada Inn, Cocoa Beach, Fla., Apr. 20-22.

Seminar on Nonlinear Partial Differential Equations in Mathematical Physics, sponsored by Air Force Office of Scientific Research, Army Research Office, and American Mathematical Society, Hotel New Yorker, New York City, Apr. 20-23.

AFIPS, IEEE and ACM Spring Joint Computer Conference, Sheraton Park Hotel, Washington, D.C., Apr. 21-23.

IEEE Southwest Conference and Electronics Show, Dallas Memorial Auditorium, Dallas, Apr. 22-24.

American Geophysical Union, Annual National Meeting, Washington, D.C., Apr. 22-25.

Fourth Rare-Earth Research Conference, sponsored by Air Force Office of Scientific Research, Phoenix, Ariz., Apr. 22-25.

National Aeronautics Meeting and Production Forum, sponsored by SAE and ASME, Commodore Hotel, New York City, Apr. 27-30.

MAY

American Society for Microbiology, Sheraton Park and Shoreham Hotels, Washington, D.C., May 3-7.

10th National Aerospace Instrumentation Symposium, sponsored by ISA, Biltmore Hotel, New York City, May 4-6.

AIAA Aerospace Propulsion Meeting, Cleveland, May 4-6 (semi-classified).

10th Annual Meeting of the American Astronautical Society, Hilton Hotel, New York City, May 4-7.

ASME Metals Engineering Conference, Sheraton-Cadillac Hotel, Detroit, May 4-8.

Fifth National Symposium on Human Factors in Electronics, sponsored by IEEE-HFE, San Diego, Calif., May 5-6.

IEEE-EIA Electronic Components Conference, Marriott Twin Bridges Motor Hotel, Washington, D.C., May 5-7.

Society for Experimental Stress Analysis Spring Meeting, Hotel Utah and Motor Lodge, Salt Lake City, May 6-8.

Acoustical Society of America Spring Meeting, Hotel New Yorker, New York City, May 6-9.

COSPAR Seventh Plenary Meeting, Florence, Italy, May 8-20.

International Conference of the Society of Aerospace Photography Engineers and Technicians, Palisades Park, N.J., May 10-15.

IEEE-ANE-AIAA National Aerospace Electronics Conference, Biltmore Hotel, Dayton, Ohio, May 11-13.

Symposium on Applied Mathematics and Mechanics in Honor of Theodore von Karman, sponsored by Air Force Office of Scientific Research and the Society for Industrial and Applied Mathematics, Washington, D.C., May 11-14.

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Alma Maters or Madams?

GOVERNMENT FUNDING of basic research has shown a strong growth in recent years. This can be expected to continue, particularly as the Dept. of Defense firms up its view of basic research as it relates to the ultimate development of military hardware.

This emerging DOD philosophy was well stated last week by the chief of Air Force Systems Command research and technology, Maj. Gen. Marvin C. Demler, in a Los Angeles address. He noted that the quickest and frequently the cheapest way to achieve many research objectives is to try multiple paths.

"More should be tried in research than in development; more in exploratory development than in weapons systems development; more in weapons systems development than will eventually be procured and made operational," Gen. Demler emphasized.

The task facing DOD management is how to assure itself that its research is going into productive channels, that it is indeed financing a true multiple-path approach rather than duplication of the same path. This is not an easy problem to solve, but DOD is making a laudable effort.

The research office of the Directorate of Defense Research and Engineering recently has been reoriented as part of this program. One of its objectives will be to convince Congress of the value of the research function. DDR&E hopes to develop documentation to identify the fruits of past research, not only to support its case for increasing funds, but to discover the productive patterns which can be followed again.

Out of this effort, if it is as successful as expected, will come further large increases in funding of basic research. The amount spent by the government in this area already is considerable.

The U.S. Statistical Abstract shows that Federal funds for basic research alone totaled $849 million in Fiscal 1962. There has been a major increase since that time, particularly as a result of the step-up in the space program.

It is interesting to note the distribution of the government's basic research spending. Of the $849 million, some $238 million was spent in-house. Eighty million dollars went to non-profit organizations, $89 million to industry and $442 million to universities.

Thus, more than half the money spent by the government in basic research was spent with the universities. By far, the bulk of these funds came from the defense and space programs.

It also is interesting to note what the trend has been in this regard. In the three-year period up to Fiscal 1962, basic research funding increased by $45 million at the non-profit level, $46 million at the industry level, $58 million in-house—and $186 million at the university level.

This brings us to a major question which DOD is attempting to answer in its approach to the research problem: How can the U.S. spend its basic research funds for defense to the best advantage?

We suggest that one method is to take a close look at what the wealth of both basic and research funds has done to the nation's universities. It must be asked whether this step-up in financing has brought a proportionate increase in the amount of first-rate research being carried out by the colleges and universities. A close look at the situation suggests that much of what the increase has purchased has been second- and third-rate research.

Closer management of research funds, the approach being taken by the Defense Dept., is one way to improve the situation. But unless more integrity is shown at the university level, the problem will be difficult to solve.

Our universities, and their faculty members, have become prone in all too many cases to chase the research dollar to the neglect of more basic functions. Nor does the chase stop at the basic research dollar. It plunges the universities on into the fields of applied research, development, and even hardware procurement. Witness, for example, the involvement of MIT and Cal Tech in space hardware programs.

The quality of university research work is being degraded in the search for quantity. The faculty member who can bring a contract home for a multimillion-dollar cyclotron rates much higher with university management than his more scholarly colleague.

We would like to ask this question: How many universities have set up a committee to screen for true quality the ideas which faculty members carry to Washington in search of Federal funds?

All too often, individual members of the faculty stump on their own from government agency to government agency in search of a contract for what may be at best a mediocre idea.

THE UNIVERSITIES THEMSELVES are becoming internally corrupt as a result of their lack of discipline in this area. Dr. B. D. Van Evera, dean of sponsored research at George Washington University and outgoing president of the Washington Academy of Sciences, spelled this out in a recent talk.

Research and consulting, he charged, have been glamorized until they are considered to be the chief end of man, with a resulting discouragement of excellence in teaching.

Campuses are plagued with "stupid university administration" which evaluates professors on the basis of research or consulting rather than on the basis of their teaching.

There follows from this a policy of "publish or perish" which has as its goal, not the transmission of one's findings to fellow scientists, but a promotion on the university staff.

By tradition, our universities are the guardians of our culture. If they fail as keepers of the morals and standards in this field where they are the major recipient of funds, they become no more than another government contractor.

The nature of their institution is up to them.

William J. Coughlin

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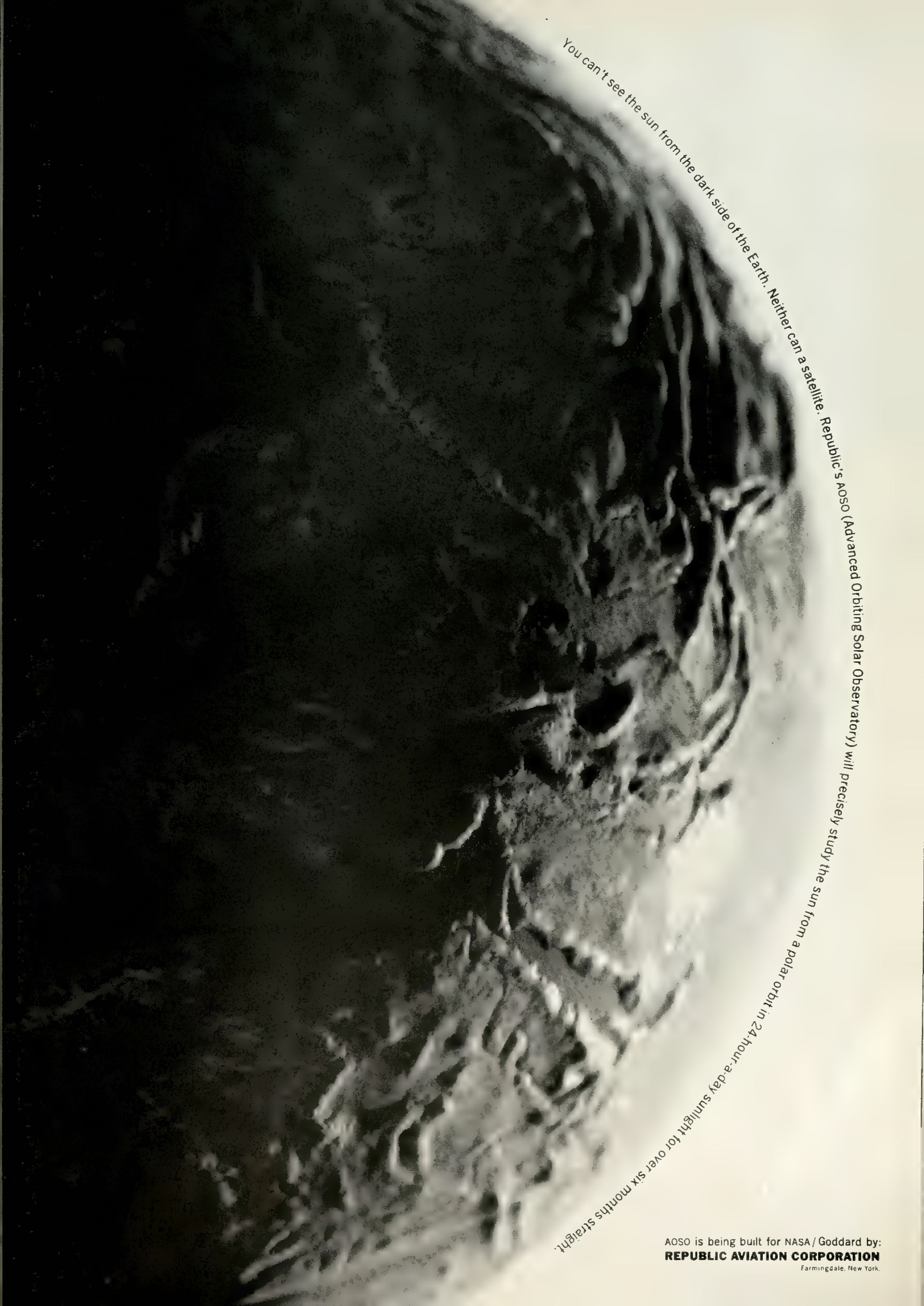
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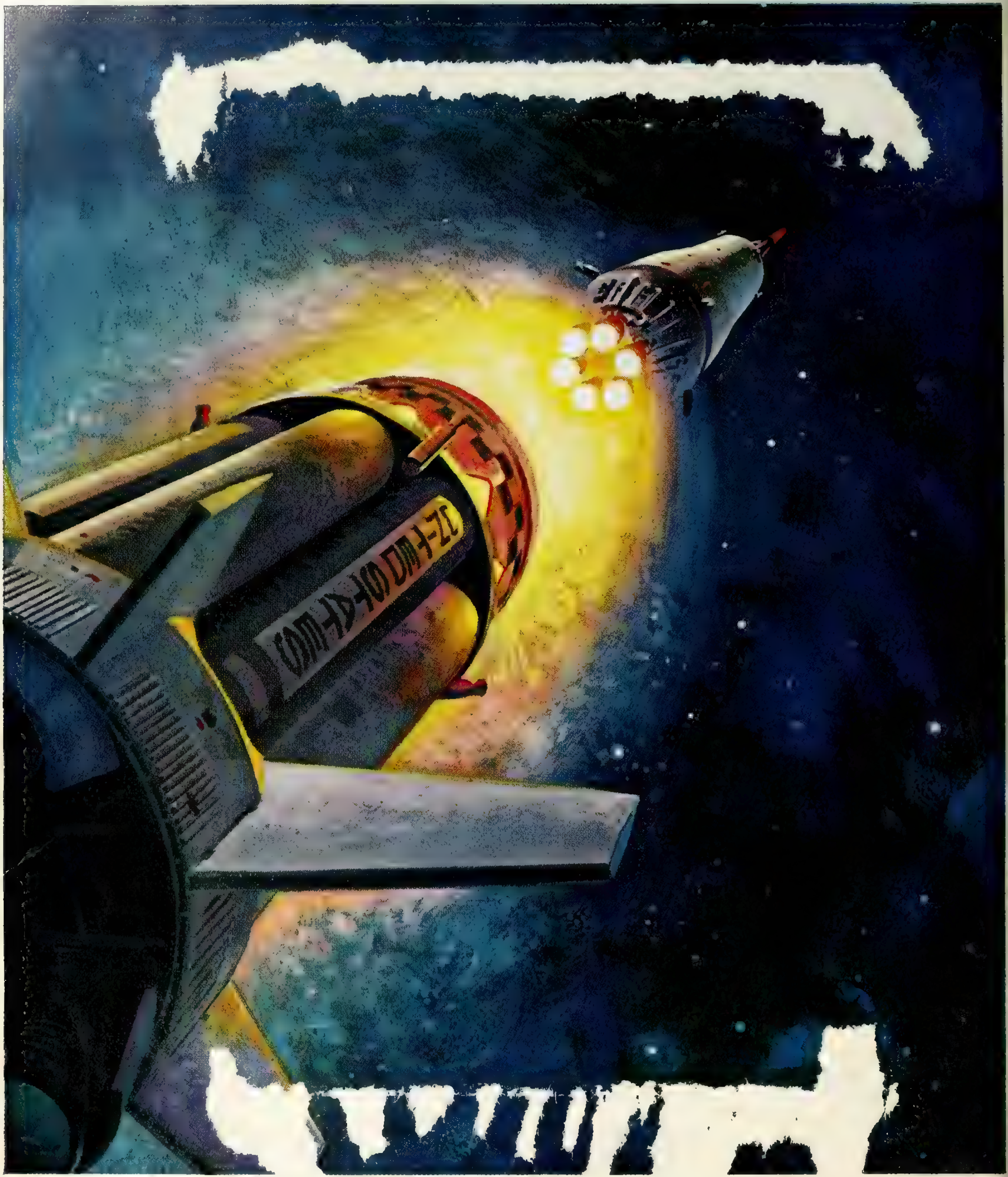

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MARCH 30, 1964

missiles and rockets

HE WEEKLY OF SPACE SYSTEMS ENGINEERING

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ANNUAL MILITARY SYSTEMS ISSUE

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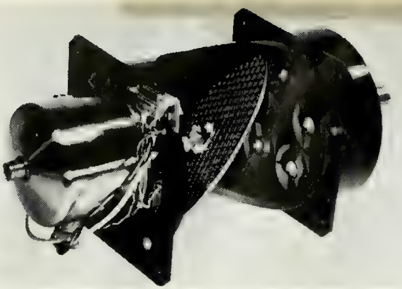
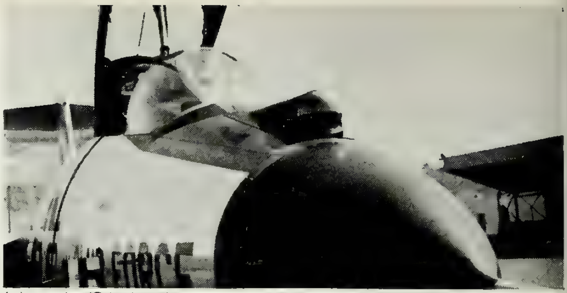
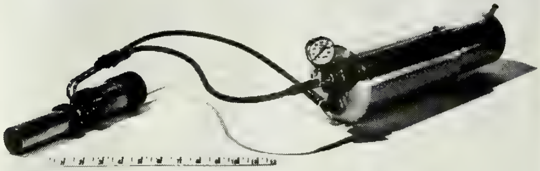


Radiometer for NIMBUS weather satellite



Interceptor IR installation



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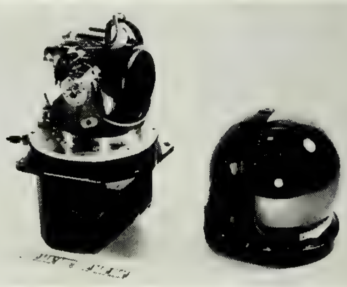
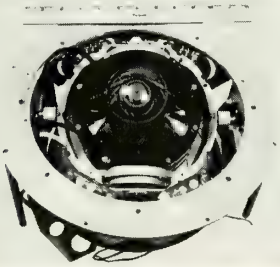
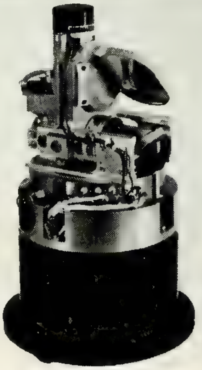


90C IR search/track set



IR multi-channel tracking radiometer



Star tracker for SURVEYOR spacecraft

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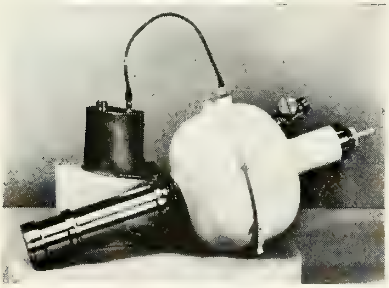

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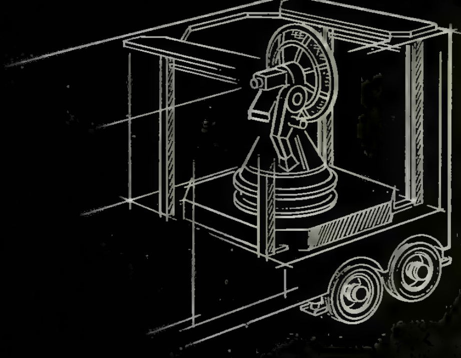

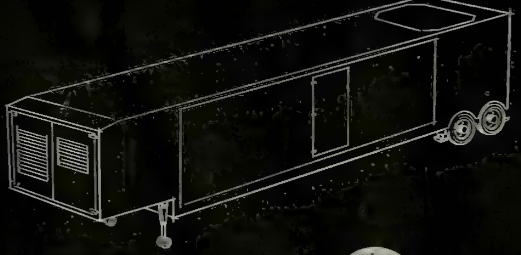

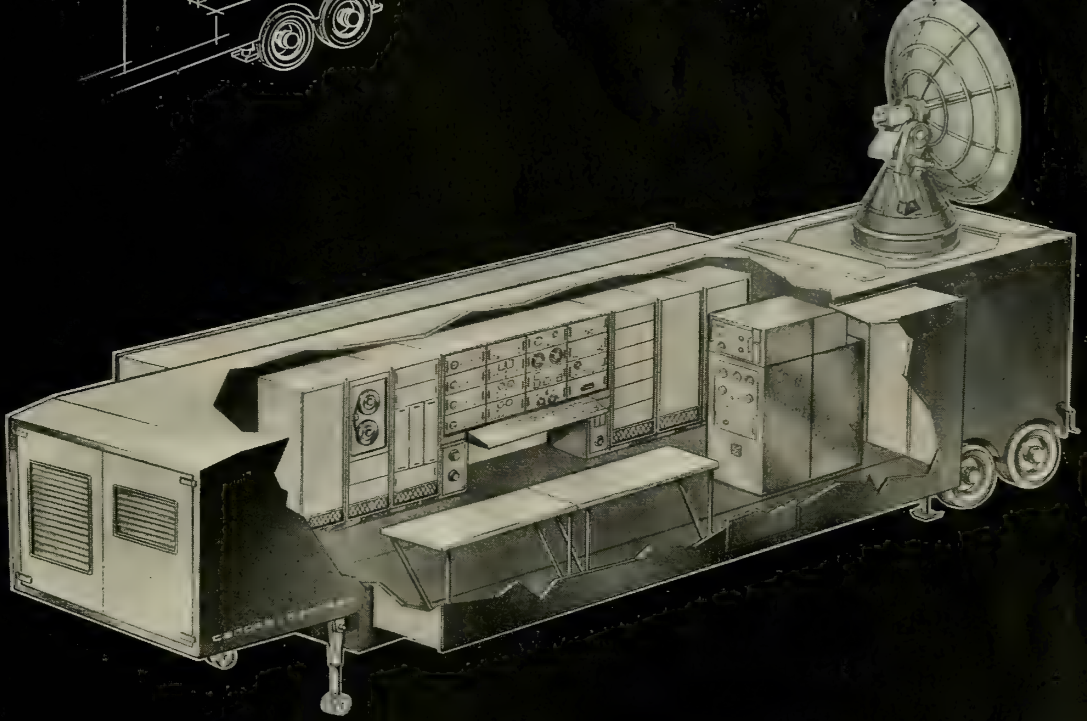

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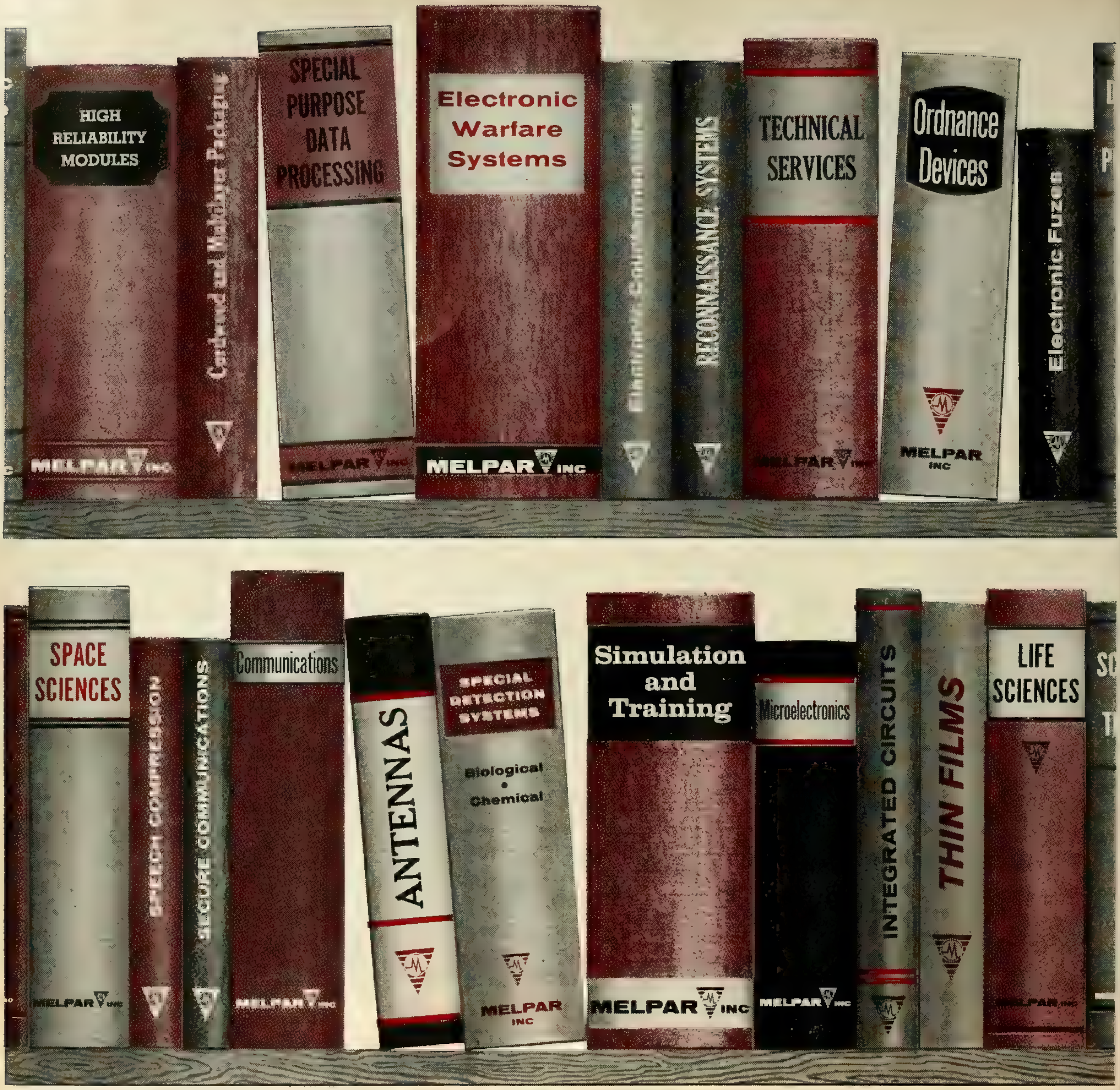
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THE COVER

Dr. Harold Brown, Director of Defense Research and Enginering for over three years, presides over an organization that has steadily increased its power over the nation's weapons development. M/R's Special Military Systems issue, devoted to DDR&E, begins on page 27.

missiles and rockets
ANNUAL MILITARY SYSTEMS ISSUE

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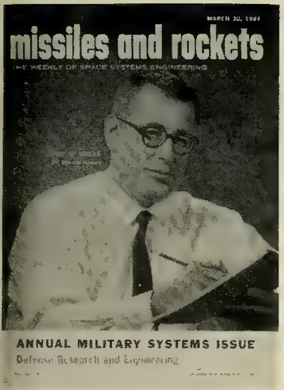
MARCH 30, 1964
missiles and rockets
THE WEEKLY OF SPACE SYSTEMS ENGINEERING
ANNUAL MILITARY SYSTEMS ISSUE
Defense Research and Engineering

THIS ISSUE of MISSILES AND ROCKETS, devoted to the Office of the Director of Defense Research and Engineering, is the result of two months' preparation by an M/R editorial task force under the direction of Military Editor Jim Trainor. DD-R&E was chosen as the subject of the special issue because of the many changes in the direction of government spending and the shifting relationship between the organization and the services.

The entire staff of M/R was gratified by the cooperation and open-handed manner of the officials in DDR&E. They gave freely of their time, and often expressed the belief that the magazine was performing a valuable service to both the industry and their organization. They feel that there has been misunderstanding and distrust of DDR&E within industry, and that this special report can do much to dispel this "set."

More than 50 individuals were interviewed during the compilation of the report. To ensure a maximum exchange of information between these officials and our staff, the interviews were all held on a non-attribution basis, with the proviso that if an editor wanted to quote a specific person, he would submit that portion of the article for approval. Quotations in the public domain, such as Congressional testimony, were of course not subject to this restriction.

* * * * * * *

IN RECENT TALKS with industry leaders, I have observed that there is considerable feeling that the defense market is shrinking. This is not true. This market always has been and always will be one of changing requirements. Each time we go through such a change, there are some predictions that the market is dwindling.

Now we are shifting emphasis from a strategic to a tactical type of defense requirement, as pointed out in the articles in this issue and in the editorial on page 148. This means that the defense contractors who have maintained good market intelligence will continue to serve the customer they know best. Those who have not kept pace probably will have to find something else to do. Any company which does not want to go through a periodic change in customer requirements had better find new markets to explore.

The future for the defense market is bright, but competing in it demands increased marketing and sales know-how. Like any other market, it is essentially a buying-and-selling exercise performed by people. We hope that this issue will help industry to play its role with greater efficiency.

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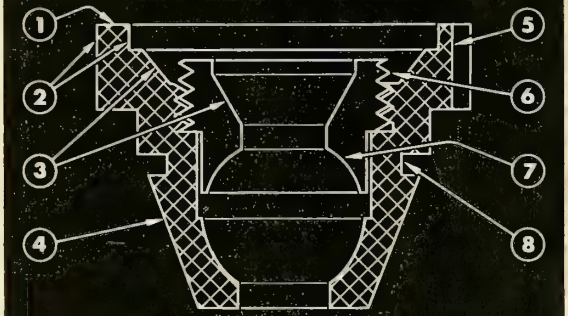

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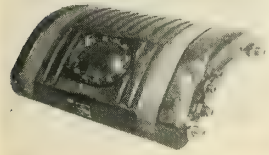

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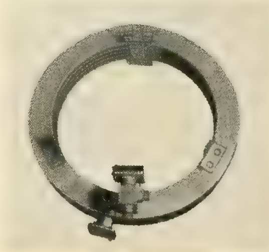

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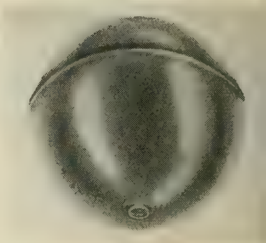

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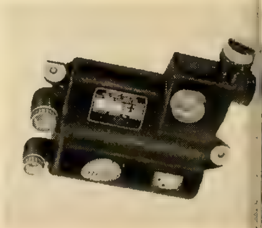
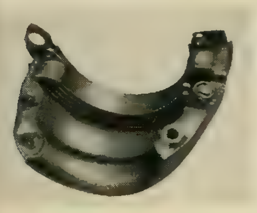
Kearfott Company, Inc.
The W. Kellogg Co.
Walter Kidde & Company, Inc.
W. S. Kirkpatrick & Company
K. L. M. Royal Dutch Airlines
Koehler Aircraft Products, Inc.
LAI—Italian Airlines
Lear, Inc.



Helicopter Engine Oil Cooler

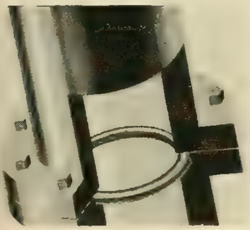
The Leland Electric Co.
J. W. Lawrence, Ltd.
Lincoln Mercury Div., Ford Motor
Linea Aerea Nacional—Chile
Santiago, Chile

Link Div. General Precision
Lockheed Aircraft Corporation
Lockheed Aircraft Service, Inc.
Lycoming Div. Avco Corp.
McCulloch Motors Corp.



Oil Tank and Cooler

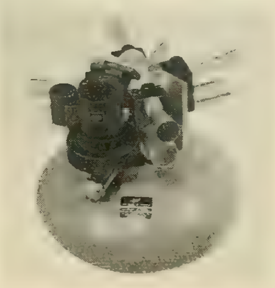
McDonnell Aircraft Corp.
Willard McGary Company
Marquardt Aircraft Corporation
Martin-Marietta Corp.
Maryland Aviation Research Corp.
Massachusetts Inst. of Technology
W. L. Maxon Corporation
Minneapolis Honeywell Regulator Co.
Modern Plastic Corp.
A. J. Moore, Inc.
National Airlines, Inc.



O-Rings for pressure tight joints and permanent non-corrosive seals

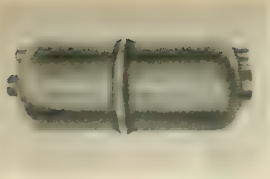
National Supply Co.
New Zealand Government
Walnut Div.
Norris-Thermador Corp.
North American Aviation, Inc.
North Carolina Pulp Company
Northwestern Aeronautical Co.
Edmonton, Alberta, Canada
Northwest Orient Airlines
Northwest Industries Ltd.
Edmonton, Alberta, Canada
Ohio Aviation Co.
Olin Mathieson Chemical Corp.
Orenda Engines Div. Hawker Siddeley
Pacific Airmotive Corp.
Pacific Western Airlines, Ltd.
Vancouver, B.C., Canada
Pan American Carburetor Service
Pan American World Airways Stystem
Patlon Aircraft
Pesco Products Div.
Borg-Warner Corp.
Piedmont Aviation, Inc.
Pioneer Aero Service
Pioneer-Central Division
Bendix Aviation Corp.
Procter & Gamble Company
Prairie Equipment & Radiators, Ltd.
Winnipeg, Man., Canada

Pratt & Whitney Div. UAC
Precision Aeromotive Corp.
Purdue Aeronautics Corp.
Rheem Mfg. Co.
Republic of Indonesia
Radio Corporation of America
Raytheon Mfg. Company
Reaction Motors, Inc.
Remington Rand Company
Republic Aviation Corp.
Republic Steel Corp.
George D. Roper Company
Richey Air Sales
Robertshaw-Fulton Controls Co.
Rocketdyne Div., NAA



All Attitude Control System

Rohr Aircraft Corp.
Rolls-Royce of Canada, Ltd.
Ross & Lehman Co.
Rotron Research Corp.
Royal Canadian Mounted Police
"Air Division"
Ryan Aeronautical Company
S.A.A.B.
Linkoping, Sweden
Sabena Belgian Airlines
Scandinavian Airlines System
Sikorsky Aircraft Div. UAC
L. B. Smith
Thor Solberg Aviation Co.
Southern Airways, Inc.
Southwest Airmotive Co.
Southwest Airways Company
Sperry Gyroscope Co.
Standard Aero Engine, Ltd.
Winnipeg, Man., Canada
E. C. Styberg Engr. Co.
Sundstrand Corp.
Surface Combustion Corp.
Sylvania Electric Products, Inc.
Technische Handelmii Hollinda. N.V.
Temco Aerosystems Div. L.T.V.
Thiokol Chem. Corp.
Thompson Products, Inc.
Trans-Canada Airlines
Transportes Aereos—Portugueses
Lisboa, Portugal
Trans-Sonics, Inc.
Trans-World Airlines, Inc.
A. E. Ulmann & Associates, Ltd.
Union Bag-Comp Paper Corp.
Union of South Africa
Unipak Aviation Corp.



Missile Attitude Control Fluid Storage Vessel

United Aircraft Export Corp.
United Hydraulics, Inc.
U.S.C.G. Aircraft Repair & Supply Base
U. S. Navy Department
U. S. Air Force
U. S. Army
United States Overseas Airlines, Inc.

Utica Bend Corporation
Vertol Div. Boeing
Western Electric Company
Westinghouse Air Arm
Westinghouse Electric Corp.
Westwood Gage & Tool Co.
Young Radiator Co.

Engine Oil Cooler

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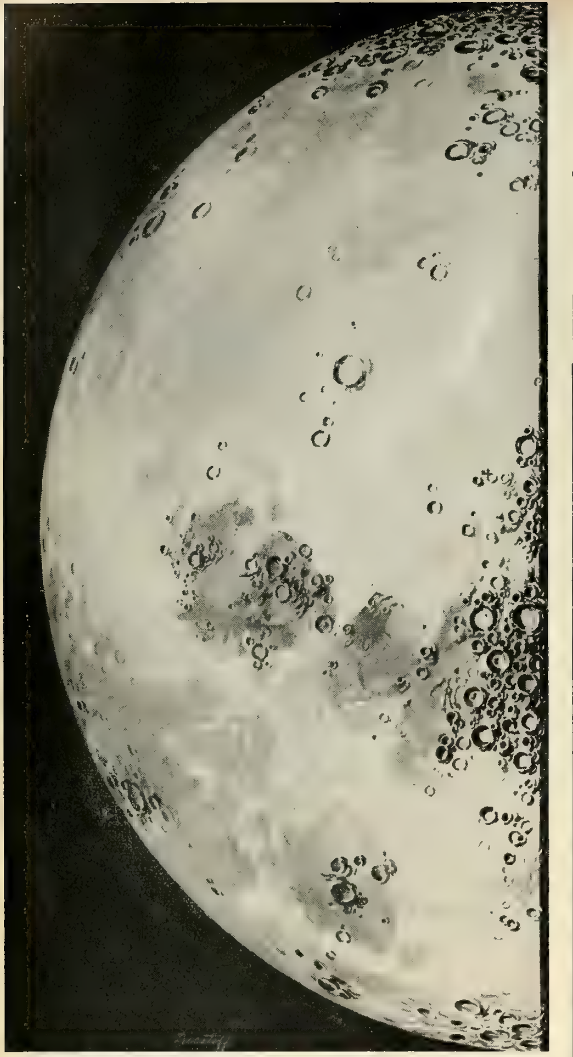
TRW SPACE TECHNOLOGY LABORATORIES In Perspective

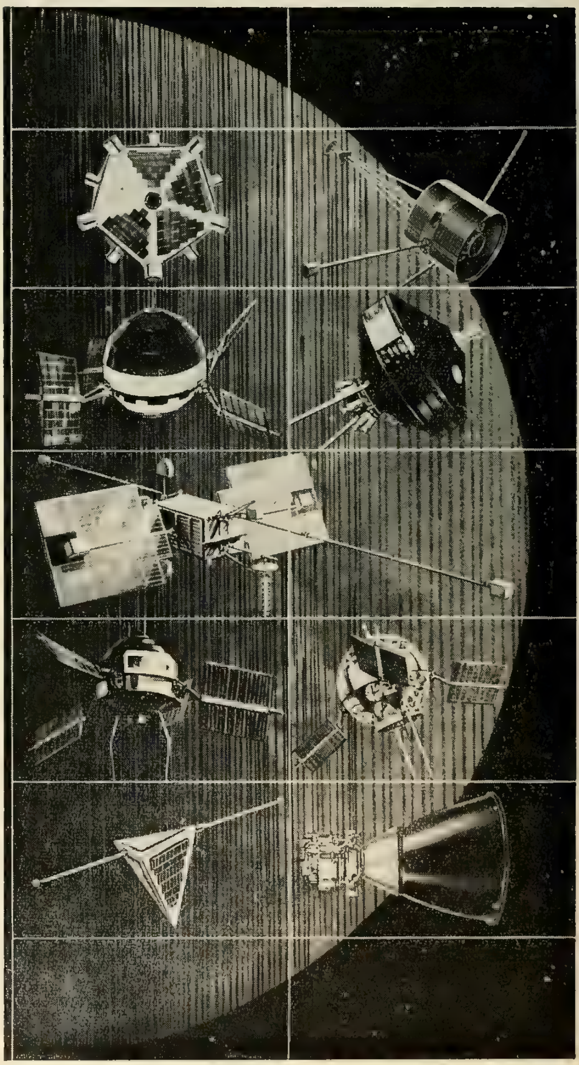


As the nation's first industrial firm devoted exclusively to missile and space technology, TRW Space Technology Laboratories grew with the national space effort. Since 1957, STL has participated in nearly every manned and unmanned space probe.

Today, 2500 engineers and scientists and 4500 support personnel combine their talents on many STL projects ranging from research and development to design and manufacture of NASA'S OGO spacecraft, Air Force nuclear test detection spacecraft, Tetrahedral Research Satellites, and NASA'S Pioneer spacecraft.

Also underway is the development of the variable-thrust rocket descent engine for LEM, the Lunar Excursion Module of Project Apollo. At the same time STL continues Systems Management for the Air Force's vital Atlas, Titan and Minuteman Programs.

These many space activities create immediate openings for engineers and scientists with experience in Theoretical Physics, Systems Engineering, Radar Systems, Experimental Physics, Applied Mathematics, Space Communications, Space Physics, Antennas and Microwaves, Inertial Guidance, Analog Computers, Solid State Physics, Computer Design, Telecommunications, Digital Computers, Guidance and Navigation, Electromechanical Devices, Engineering Mechanics, Applied Aerodynamics and Propulsion Systems.



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TRW SPACE TECHNOLOGY LABORATORIES
THOMPSON RAMO WOOLDRIDGE INC.

The Countdown

WASHINGTON

Military Voices Comsat Doubts

Some military officials are belatedly expressing fears that the DOD-Comsat Corp. agreement, if it materializes, will sacrifice a degree of military capability. The commercial system will not be as flexible as a military set-up, they feel, and won't give them as much priority as they would like.

NASA Jealous of AF Upper-Stage Move

A number of NASA officials are incensed at the Air Force's move to proceed with development of a high-energy upper stage. The Air Force will spend $5 million in FY '65 in preliminary design of the stage, which could be used on the *Titan III*. The unhappy NASA staff members believe that development of such a stage should be a space agency prerogative because its only mission would be escape-velocity flights to the Moon and planets. The Air Force is now restricted to near-Earth orbit missions.

Six Considered for ERC Director

NASA now hopes to pick a director for its new Electronics Research Center by mid-summer. Dr. Raymond Bisplinghoff, director of the Office of Advanced Research and Technology, is preparing a list of candidates. It's reported that six men—three from the agency and three outsiders—are on the list. One NASA official getting serious consideration is Dr. Albert J. Kelley, director of electronics and control. Top officials have scrapped, at least for the moment, plans to appoint an acting director. And it's been decided that NASA employees won't begin moving to the Boston center in large numbers until late fall.

Topsi, S-66 Shots Held Up

Launch of the *'Topsi'* satellite and another try at orbiting an *S-66* spacecraft have both been postponed until the June-July period or later. Lack of launch vehicles and launch pad availability are the main reasons. In addition, the *Topsi* will have to go through a complete new checkout following the scrub of its planned March flight.

Standard Missile a Weapon for '70's

Navy's "3-T" replacement, the Standardized Missile System, is not expected to be ready for the fleet before 1970. Still not firm, according to DOD, are such things as the class of ships on which the system would be deployed or the type of launch equipment to be used. Recent requests for proposals sent to 11 firms are seen as a Defense effort to enlist industry help in defining the system, rather than as a prelude to development.

Dyna-Soar Salvaging Continues

Thirty-six items that will provide technological payoffs for other programs have been identified by the Air Force through a joint ASD-R&T study. Several which are directly applicable to the *MOL* include a full-pressure suit developed for the *X-20* pilot, a new high-power personnel rescue receiver/transmitter, and information from studies of pilot control and re-entry vehicles.

MMRBM Guidance Sure to Survive

The stellar inertial guidance system for the *Mobile Medium Range Ballistic Missile* will not be scrapped regardless of what happens to the weapon itself. While planned primarily for use with the *MMRBM*, the system also will be used in DOD's Controlled Orbit and Precision Recovery Program.

NASA Ponders PMR Delta Firings

NASA is considering an improvement program for the *Delta* launch vehicle. Increased payload capacity would be used in the meteorological satellite program. Part of the decision hinges on whether the space agency wants to get involved in *Delta* launches from the Pacific Missile Range. Weather satellite firings would be made from there rather than Cape Kennedy in order to achieve the desired polar orbit.

INDUSTRY

SSD Move May Celebrate 10th Birthday

Air Force officials are trying to time a move by Space Systems Div. to its new El Segundo complex to coincide with the tenth anniversary of the Western Development Div. All SSD installations now in the Los Angeles airport area are moving to the El Segundo site, where they will share a 93-acre area with Aerospace Corp. Air Force officials had attempted to get approval for an Air Force Base designation at the site, even though it has no runways, but it now appears that the official name, to be announced early in May, will be Los Angeles Air Force Station.

Radiation Wins LEM Telemetry Award

Radiation Inc., of Melbourne, Fla., has been selected by Grumman Aircraft Engineering Corp. to provide a low-power, PCM telemetry and timing system for the *Apollo* Lunar Excursion Module. The cost-plus-fixed fee contract is worth more than $4.5 million.

Norden Color Analog System Shipped

Norden Div. of United Aircraft Corp. has delivered to NASA's Flight Research Center its first Contact Analog System employing color display. It will be used to test pilot reactions in vehicle simulators to develop better control systems for future spacecraft.

INTERNATIONAL

First Japan-U.S. Live TV Successful

Prime Minister Hayato Ikeda spoke in the first live TV broadcast from Japan to the U.S. on March 25. He used the facilities provided by the *Relay II* satellite to apologize for the stabbing of American Ambassador Edwin O. Reischauer by a mentally disturbed Japanese student. The 8-min. broadcast, which also showed scenes of Tokyo, was telecast on NBC. Both picture and sound were excellent.

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THIS "REVOLUTION" IN RANGE TECHNOLOGY NEVER ENDS—it's a continuous process, pacing the progress of the nation's space and missile programs.

Right now plans are being readied to meet range test requirements of TITAN III missiles, the Gemini program, Advanced Saturn Boosters, Apollo Vehicles—and the Advanced Planning Group is projecting range instrumentation needs up to 15 years ahead.

The GMRD effort draws on nearly every engineering and scientific discipline in the book—from celestial mechanics to microwave, from operations analysis to undersea sound—with a major emphasis on systems engineering.

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Electronics Executives View Future

NEW YORK—A $1.5-billion potential market for integrated circuits in 1973 will generate an actual market estimated at $750 million, in the view of Patrick Haggerty, president of Texas Instruments, Inc., of Dallas.

Haggerty followed up this prediction by suggesting that this level of IC sales also would result in an actual saving to the industry of $1 billion when weighed against the costs of using conventional circuitry. The potential saving to the industry is double that figure, he declared.

Haggerty's remarks were made before an overflow audience at an evening panel session on microelectronics at the meeting of the Institute of Electrical and Electronics Engineers (IEEE) here.

If the initial $1-billion saving does develop, reported Haggerty, "about 70% of it will accrue to the government sector, which would represent a healthy 7% decrease in the total cost of government electronics in 1973."

- **Four out of five**—The panel discussion outdrew any other technical session at the four-day meeting. Five other top-level industry executives served on the panel. Moderator-panelist Haggerty introduced them as "one beautiful customer and four ugly competitors."

In addition to the TI chief, the speakers were: C. Lester Hogan, general manager of Motorola's Semiconductor Products Div.; Robert N. Noyce, general manager, Semiconductor Div., Fairchild Camera and Instrument Co.; Leonard C. Maier, general manager of General Electric's Semiconductor Div.; Harry Knowles, manager of Westinghouse's Molecular Electronics Div.; and J. E. Brown, vice president of Zenith Corp.

Another top manufacturer of integrated circuits large enough to be classified as "ugly"—the Signetics Corp.—was conspicuously absent from a panel which included four of the generally agreed-upon five top suppliers of IC's.

Haggerty estimated a total electronics market by 1973 of $20.1 billion, which could in fact be reduced slightly due to projected savings through use of IC's. Cost of circuits utilized in this equipment will be about 30% of total sales, or about $5.8 billion. Haggerty believes about 80% of the circuitry used for government equipments by 1973 will be both technically and economically replaceable by integrated circuits, thus generating the potential pressure for conversion to the microcircuits.

Haggerty pointed out the growth in the field already and the ability to deliver circuits. The total 1963 IC market hit about 950,000 units, worth some $21.4 million. However, nearly half the half-million total SCN's shipped were delivered during the fourth quarter, four times as many as were shipped in the first quarter. At the end of 1962, Haggerty said, there were about 30 different types of SCN's. At the end of '63, about 132 types were being produced.

- **Attack on parasitics**—Motorola's Les Hogan laid heavy emphasis on the efforts to develop essentially parasitic-free monolithic silicon circuits. The parasitic capacitance of P-N junctions has been one of the major degradations associated with SIC's, and has hampered development of linear circuits. It has also created pressure for more thin-film and hybrid work.

Hogan reported in detail on Motorola's solution to the problem, noting that it is now building parasitic-free circuits in a pilot line. He predicted wide-scale commercial use next year.

In the Motorola "EPIC" process, the new circuits are made by all the same processes as earlier devices, but now an insulating layer separates each isolation island from the supporting silicon substrate. The extra processing involved, says Hogan, will add about a half-cent to the cost of the finished IC in full production. The layer thickness can be increased to reduce effective capacitance to zero.

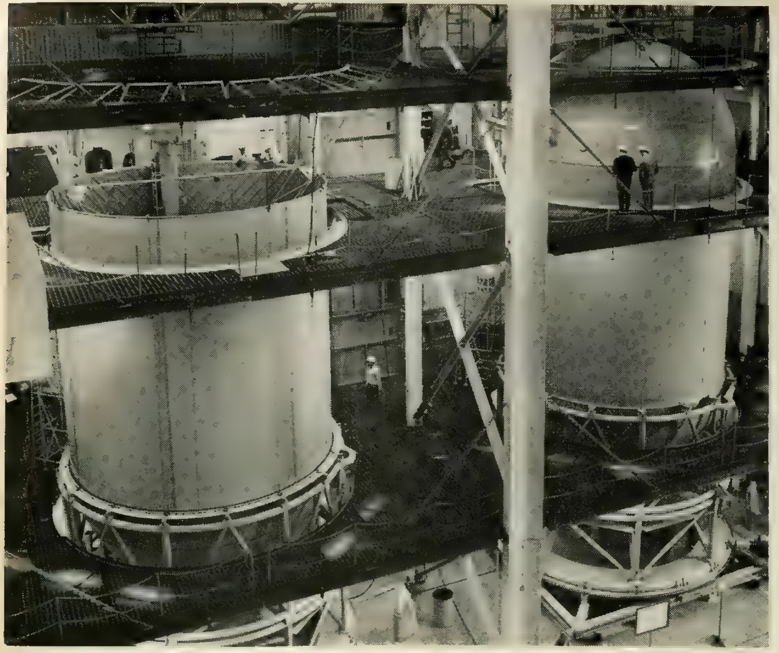
- **Further potentials**—In other projections, Hogan said that thin magnetic films promise storage capacity as great as 10 million bits and cycle times of 100 nanosecs. Superconducting films promise memories with capacities greater than one billion bits with cycle times as fast as a microsec. Both circuitry types will be limited to computer memory use, according to Hogan.

He emphasized that monolithic silicon will have the edge in digital circuits applications through cost alone. He was backed up in another strong statement regarding the still untapped potential of SIC's by Westinghouse's Harry Knowles. Hogan also added that "vast data on yields on our standard IC and transistor lines indicate that yield for IC's is roughly the same as that of the very critical transistors now produced."

In addition, the Motorola executive dwelled on the trade-offs in choosing when to put passive components on silicon and when to put them on an insulating substrate and attach the active elements. In general, the die space required for the passive elements is the determing factor.

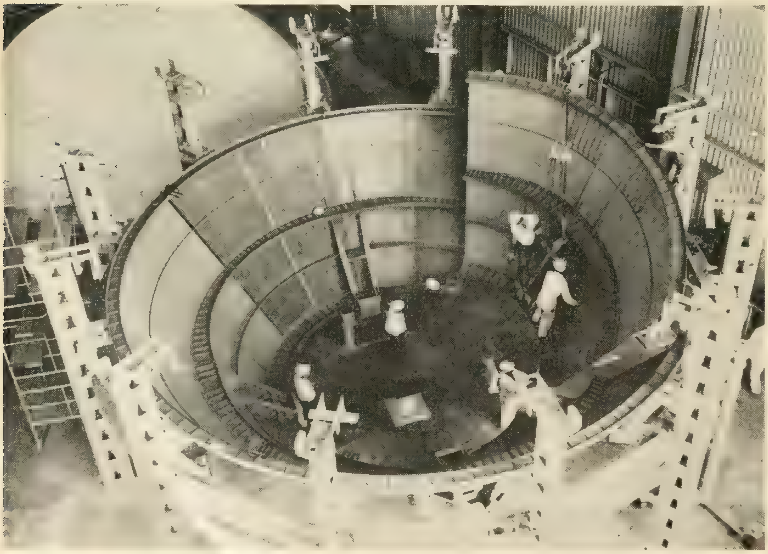
Roughly, he reported, if the area devoted to passive elements is just equal to the area of active elements, it probably is cheaper to use the silicon substrate than to pay for interconnection problems. The technique favored tips to thin-film passive components and attached active devices if the passive components occupy most of the space.

Knowles—while plugging for development of what he sees as still another order of magnitude in performance to be gained with monolithic silicon circuits (which he feels will remain principally in the 12-lead flat-pack configuration)—also sees considerable advantages to come with greater use of electron beam-generated devices, silicon memory elements and advanced linear circuits, such as were beginning to show up at the current IEEE meeting.



Saturn Hardware Takes Shape at Douglas, NAA

ABOVE: First two S-IVB stage propellant tanks for NASA's Saturn launch vehicle near completion at Douglas Space Systems Center, Huntington Beach, Calif. Welding has been completed on vehicle at right. At left, LOX tank, which includes the common bulkhead separating LOX and liquid hydrogen tanks, is welded to cylindrical tank section. BELOW: First flight-type hardware for S-II second stage of Saturn V is placed in assembly jigs at North American Aviation's Space Div., Seal Beach, Calif. It will be used for ground tests. Huge aluminum quarter panels, joined with aft skirt, will form thrust structure of S-II stage. S-IVB will be top stage of the Saturn V Apollo booster and second stage of Saturn IB.



NASA Voted $5.194 Billion

The House of Representatives passed NASA's $5.194-billion Fiscal Year 1965 authorization bill as reported by the House Space Committee after a last-ditch struggle over the Electronics Research Center.

The vote was 283 to 73.

The bill calls for $4,327,950,000 for research and development, $248,335,000 for construction of facilities, and $617,525,500 for administrative operations. This amounts to a cut of more than $110 million from NASA's overall request, of which $54 million is taken from R&D. However, no R&D funds were cut from either *Apollo* or *Gemini* programs (M/R, March 16, p. 12).

One of the most heated moments during the debate came when Rep. Donald Rumsfeld (R-Ill.) introduced an amendment to cut more than $10 million intended for the Electronics Research Center. The amendment was defeated by a vote of 116 to 66.

Rumsfeld charged that the committee had never called any witnesses on the need for ERC and had been refused permission to examine other information pertaining to it.

Rep. Olin Teague (D-Tex.) said that he thought NASA had done a "poor" job of presenting the ERC, but that subsequent examination of the nation's effort in space made him believe it was needed. Rep. Carl Albert (D-Okla.), majority leader, also rose to defend the center.

● **Republican views**—In further comments on the House report, Republican committee members once again questioned the management of NASA's life sciences effort. They urged that a single official be made responsible for one central life sciences organization which would coordinate with the Dept. of Defense.

Republicans also charged that they lacked the proper staffing responsible to the minority members of the committee. They recommended that one minority staff member be hired for each subcommittee.

A resolution was introduced by Rep. Thomas M. Pelly (R-Wash.) to extend the lunar-landing deadline to "sometime before 1975." He said in offering it that he was "in harmony with the idea of the United States' pre-eminence in space" but he advocated "a more deliberate pace. Pelly indicated he felt that the $1-billion-a-year overrun cost which has been quoted by NASA was unrealistic.

The Senate Space Committee has completed hearings and is expected to start marking up the Senate version of the bill within the next several weeks.

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Lockheed optics research offers key to new signal processing technique

Advanced research in optical techniques has opened exciting new horizons in signal processing at Lockheed Electronics. A Lockheed-developed optical pulse compressor may lead to a significant increase in range and resolution of radar systems. Next-generation computers using these same light beam techniques may replace electronic circuitry with hardware one-tenth its size and weight.

Optics is but one of the important research and development projects at Lockheed Electronics. Another is 3-D target display for radar. A third is a hydrophone system so sensitive it can detect and identify hundreds of separate underseas sounds. Man-pack radar is yet a fourth key effort... reducing to the size of a single soldier's pack a complete radar transmitter-receiver.

These are just a few of the significant "R&D" projects under way at Lockheed Electronics. Many are company-funded. Several have already yielded technological advances that are earning Lockheed increased responsibility in key military and space projects.

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Shots of the Week

NASA lost contact with the *Beacon Explorer* satellite (formerly known as *S-66*) it launched Mar. 19 from Cape Kennedy 22 seconds after third-stage ignition of the *Delta* booster. *Beacon Explorer* was to have reflected back to Earth laser rays fired at it from Wallops Island, Va. The *Delta* failure was the first in 23 consecutive firings by the space agency. The Air Force on Mar. 24 lost an *ASSET* materials testing vehicle when the second stage of its *Thor-Delta* vehicle misfired, causing *ASSET* to fall into the Atlantic some 500 mi. southeast of its Cape Kennedy launch site. First flight of the vehicle last September ended in partial failure when, after a successful flight into space, the Air Force failed to recover it before it sank in the ocean (M/R, Sept. 23, p. 18).

- The Air Force launched a *Titan II* ICBM on a successful test flight Mar. 23 from Cape Kennedy. The nose cone, which was propelled 5,000 mi. into the planned target area, carried a version of the malfunction detection system that will warn *Gemini* occupants of any difficulty in the *Titan II* launch vehicle during powered phase of a *Gemini* mission.
- An operational training flight of the *Minuteman* was successfully conducted by an Air Force crew from Vandenberg AFB, Calif. Mar. 24.
- A *Minuteman* ICBM successfully flew a 5,000-mile course from Cape Kennedy March 20, reaching a 500-mile altitude before impacting near Ascension Island in the South Atlantic. It was the 50th missile launched in the Air Force's *Minuteman* test program which began Feb. 1, 1961.
- A *Minuteman* ICBM exploded shortly after launch from a silo at Vandenberg AFB, Calif., on Mar. 25. Cause of the explosion was being investigated.

Big Solids Extension Is Shaky

A top space agency official declares that Phase I of the 260-in.-dia. solid motor program will have to be almost 100% successful if actual firing of full-length motors is to be approved.

A. O. Tishler, director of propulsion in the Office of Advanced Research and Technology, says there is no mission requirement for the program.

"Its only justification is that the big solid booster can be developed quickly and cheaply."

He said that if trouble develops in Phase I, which calls for firings of four half-length 260-in. motors, there is a very good chance that Phase II will not be approved by NASA.

Direction of the 260-in. motor feasibility demonstration program will shift from the Air Force to NASA in Fiscal Year 1965. Under Phase I, two contractors—Thiokol Chemical Corp. and Aerojet-General Corp.—will each fire two of the half-length motors.

Tishler says that the Phase I program has been a pleasant surprise so far in that it has been "fairly successful all the way around."

He said tanks for the half-length motors will be delivered in four months, with the first firing expected about this time next year.

If Phase II is to move ahead, funds will have to be included in the space agency's FY '66 budget. The decision will be made in October. It has been estimated that Phase II will cost about $50 million.

Pershing Bound for Europe

The Army is set to deploy the *Pershing* tactical missile to its European command next month, replacing the *Redstone* missile, which has been there since 1958.

The U.S. Army, Europe, will be joined by the 4th Battalion, 41st Artillery (*Pershing*), which will provide heavy artillery support for the Seventh Army. The 4th, consisting of four *Pershing* batteries, has been conducting tactical training missions with the so-called shoot-and-scoot missile at Ft. Sill, Okla., since late last year.

Pershing has a 400-mi. range, as compared to 200 mi. for the *Redstone,* and is considerably more mobile. It is normally transported on full-tracked tactical ground vehicles, but can also be airlifted by the Army's Chinook helicopters.

M-1 Engine Gets Go-ahead

Aerojet-General Corp.'s $270-million contract for the M-1 engine calls for the 1.5-million-lb.-thrust liquid hydrogen powerplant to pass its Preliminary Flight Rating Test (PFRT) in 1971.

The long-awaited go-ahead for the program—first announced in 1962—was signaled by the signing of the contract by NASA and the firm Mar. 25.

In its final form, the contract represents a three-year stretchout in the program and a resulting additional cost of $60 million.

Previously, the engine was to have cost around $210 million, with the PFRT in 1968.

The development schedule was delayed by heavy Congressional cuts in the space agency's FY '64 budget and the lack of any firm requirement for an upper stage that could use the M-1.

A NASA official said the decision to go ahead with the program was based on assurances from Congressional committees that they are prepared to fund the project at the necessary levels.

Current plans call for a budget in FY '66 at about the FY '65 level of $24 million. By FY '68, the funding will probably reach $60 to $70 million per year.

Under the new schedule, the first hot static firing of the engine is slated for 1966. Some agency officials had hoped to have it one year earlier. They believe that the earlier date would have given them a needed grace period if difficult technical problems develop when the engine is assembled.

Other program milestones call for a thrust chamber firing (scheduled for last week), a turbopump test this summer and a hot thrust chamber test in August or September.

The engine will be 26 ft. high and measure 17 ft. across the nozzle exit.

While there is currently no mission for the M-1, it will be used to power the upper stages of post-*Saturn V* class launch vehicles. Under its current schedule, according to NASA officials, it is unlikely that it can be flight-tested until 1975 or later.

The new contract covers only Aerojet-General's work through the PFRT. Man-rating of the engine and procurement of actual flight hardware will be included in future contracts.

Under the terms of the contract, the firm will build three complexes for ground testing the complete engine.

These will include a transient start stand, a two-position stand for long-duration firings with altitude simulation and prestart conditioning, and a stand for extended-duration runs to provide reliability determinations. The latter will also be used for tests in any engine improvement program prior to vehicle usage.

NASA Gets First F-1 Stand

NASA has accepted the first of three new F-1 engine test stands at the rocket engine test site, Edwards AFB, Calif.

Checkout of the stand will begin immediately, and the first engine acceptance test on the stand is sched-

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uled in June, NASA officials disclosed.

The F-1 is being developed for NASA, under the technical direction of the Marshall Space Flight Center, by Rocketdyne Div. of North American Aviation, Inc.

Each of the stands will be capable of testing an F-1 engine at its full thrust for periods up to 2½ minutes.

The new stands are constructed of concrete and steel, measuring 100 x 150 ft. at the base and about 175 ft. in height. They are located about 950 ft. apart and are connected to the control center blockhouse by an instrumentation tunnel.

ComSat, DOD Seek Accord

To get the Defense Dept. as a client the Communications Satellite Corp. may have to lease to it up to one-half of the capacity of the corporation's global system, which ComSat hopes to have in operation by 1966-67.

If ComSat and DOD can reach agreement on this and other points, DOD might become ComSat's biggest customer.

ComSat's bid for DOD business also may be tipping the scale toward selection of a medium-altitude, random-orbit satellite system. DOD wants a minimum of 18 medium-altitude satellites in any communications system serving its needs.

ComSat president Joseph Charyk has indicated that issuance of Phase I contracts on the first global system is imminent. This, coupled with the DOD criteria, is increasing speculation that either the American Telephone & Telegraph-Radio Corp. of America team or Aeronutronic Div. of Philco Corp. will get the award.

Meanwhile, nearly 200 communications firms filed applications before the Mar. 23 deadline with the Federal Communications Commission to invest in ComSat. Most were independent of American Telephone & Telegraph Co. affiliation.

Boston ERC Site Report Due

A report on a preferred site for the Electronics Research Center in the greater Boston area is expected in two to three weeks.

The selection will be made by a special six-man committee announced by the space agency last week.

The group will evaluate sites which have been proposed to NASA as well as any other sites the committee feels merit attention.

Criteria for the selection includes proximity to educational institutions that have graduate programs in electrical engineering, closeness to industrial firms engaged in electronics research, engineering considerations affecting construction, and problems relating to electrical interference.

The final decision on the site will be made by NASA Administrator James E. Webb after the committee submits its report.

The chairman of the group is Col. R. P. Young, executive officer, NASA Headquarters. Other members are Ralph Ulmer, Office of Construction; Anthony A. Minichiello, Electronics Research Task Group; John W. Walker, chief of Communications and Tracking, Office of Advanced Research and Technology; Harold Crate, Facilities and Models Branch, Langley Research Center; and James B. Cahalane, Northeastern Operations Office.

Minuteman Phase Completed

Aerojet-General Corp. has delivered the last of a series of *Minuteman* second-stage propellant rocket motors to Cape Kennedy for flight testing. This completes the development program for motors in the

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Wing II through Wing VI configuration.

Aerojet's Solid Rocket Plant is continuing development of the Wing VI second stage, featuring a single nozzle, larger combustion chamber and more powerful propellant than previous configurations.

Test Ban Testimony Released

Testimony released recently doubts the ability of U.S. Strategic Retaliatory forces to react under conditions of nuclear blackout.

High-frequency communications circuits "dropped out instantaneously" following a high-altitude nuclear explosion and stayed out for periods ranging from 15 minutes to 4 hours. The longer period was for circuits that passed through the disturbed region of the shot, the report says.

With Defense Secretary Robert S. McNamara's emphasis on flexibility in *Minuteman* command and control systems, this could have untoward consequences on the U.S. ability to retaliate. Although most *Minuteman* silos are connected by underground cables, McNamara has sought to give them greater flexibility by equipping airborne command posts with the ability to fire the missiles. It is these radio command links that may be most seriously affected by a nuclear blackout.

Terming this a "handicap" to U.S. deterrent forces, Col. Roy J. Clinton of the Defense Atomic Support Agency told the Senate Preparedness Investigating Subcommittee last May that the Soviets had conducted their high-altitude shots at local noon—the optimum time for inducing nuclear blackout effects.

The U.S. conducted its tests at night. "Reliable extrapolation of blackout effects from a night shot to a daytime event is impossible . . . " he pointed out.

Another aspect of the blackout problem is that of blackout from the fireball itself. In this area, Defense witnesses feel that the Soviets are about as ignorant of the effects as is the U.S. Essentially, this blackout is caused by the detonation and consequent ionization and heating of the atmosphere around the burst point. This has serious consequences for the antimissile missile system.

Since ground-based radar can't "see" through the fireball, the radar must be able to see around it, or more than one radar, separately sited, must be used to look at the penetration volume from another angle.

Another ABM problem is the self-kill mechanism in which, with-

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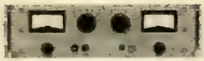
Adjustable output level −20 to −160dbm. PM and AM modulation capability within ±1db from dc to 150kc. Operates from 115V 50-400 cps or from external battery. For more information request Bulletin CSG.



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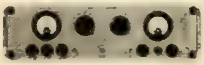

CTT-1 Test Transmitter. Single Fixed Frequency 136 to 138 mc.

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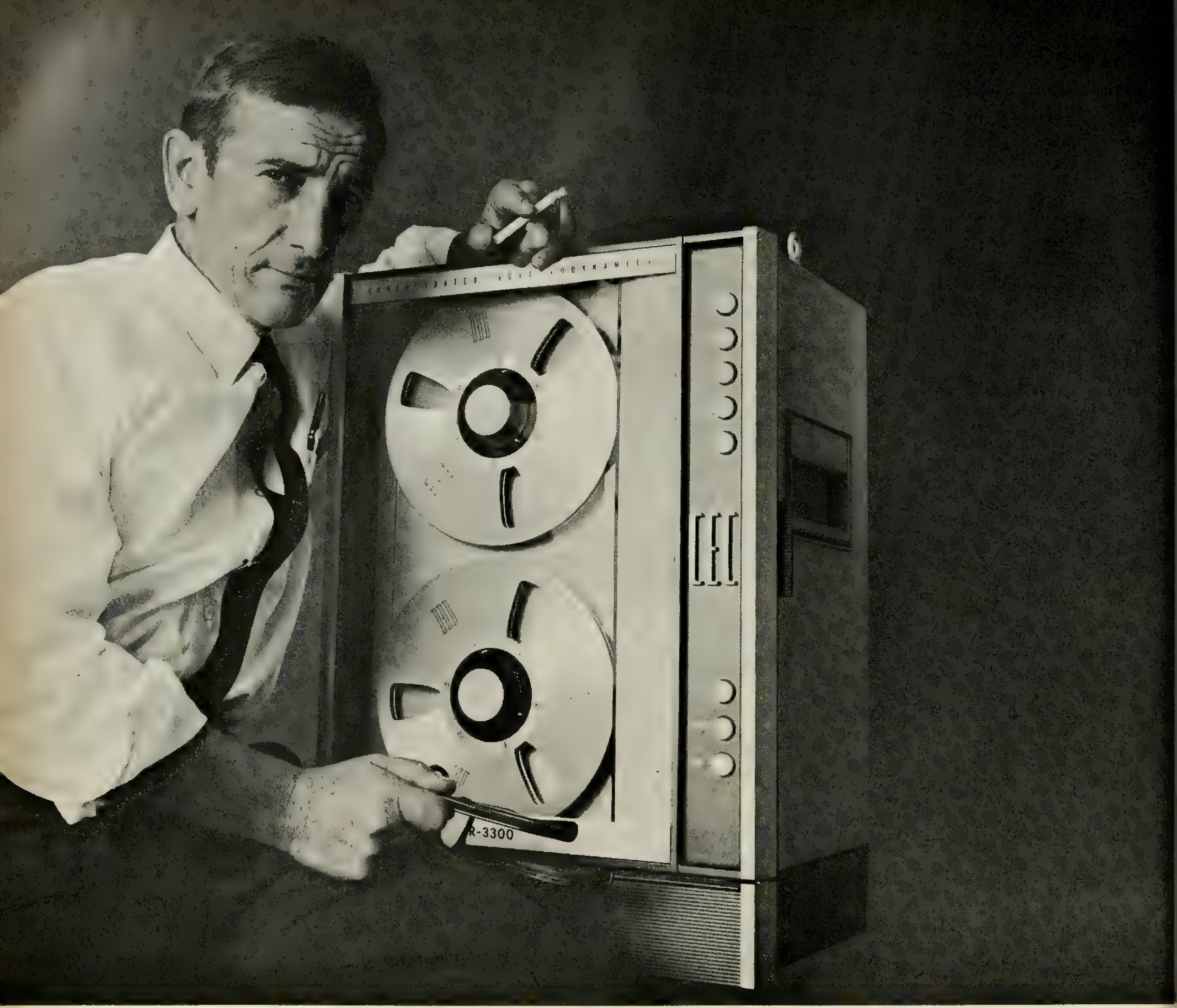

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Which posed a very complicated problem. Could CEC design an analog tape transport so simple in concept it would require virtually no maintenance, yet provide reliable performance equal or superior to the most sophisticated units?

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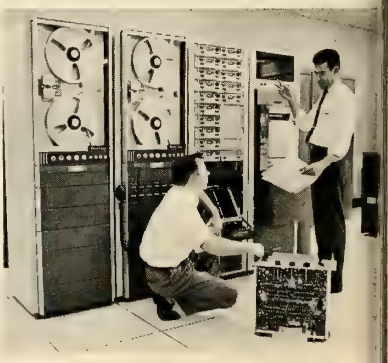
Twenty-one exhausting months later, our engineers were smiling again—and CEC was in the tape business to stay. For the industry now had a distinctly superior analog recorder, so foolproof it reduced previous maintenance time approximately 90%.

The secret was a revolutionary transport with which all adjustments were made electrically instead of mechanically. The common tool became a common voltmeter. Any operator, with a minimum of instruction, could now check and service the precision tape transport of a CEC analog recorder.

This is a prime example of how a simple approach to complex problems has benefited the customer as well as advanced CEC's leadership in the development and production of all phases of data recording.

And it also explains why CEC maintains a network of 22 sales and service offices throughout the nation. To expedite application engineering. To help train customer personnel in the use of advanced instrumentation. To explore new and better ways of advancing the state-of-the-art.



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Sensors and Pickups

Chart shows the 43 available for pressure, vibration, acceleration.

Signal Conditioners

Chart shows 11 basic types and where they may be required.

Magnetic Tape

Chart shows 8 analog and digital recorder/reproducers with support equipment.

Direct Readout

Chart shows 5 recording oscillographs, 33 galvanometers and where they can be used. Also support equipment.

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out sufficient hardening, antimissile missiles might be destroyed by defensive weapons launched previously. Underground testing can be used to overcome this problem, but in order to have complete assurance of weapon hardness, a proof test in the atmosphere would be required.

Another side of the same coin—warhead hardness—is the problem of hardening strategic retaliatory reentry bodies so that the kill radius from a defensive missile is substantially reduced. Extensive work has been done, and can be done underground, on this problem but proof would require atmospheric testing.

The hearings on the "Military Aspects and Implications of Nuclear Test Ban Proposals and Related Matters" were held in May, June and August of 1963 and only released March 22. In releasing the two-volume, 981-page transcript, Subcommittee Chairman John Stennis (D.-Miss.) asserted that it gives "an accurate and reasonably complete picture of the significant issues involved and of the views of the various witnesses."

The comparative positions of the U.S. and the Soviet Union at the time of the hearings was outlined by Defense witnesses:

—The Soviets lead in the yield range above 20 megatons;

—Approximate equality exists between the two nations in the technology of high-yield weapons below 20 megatons;

—U.S. leads in the low and intermediate range of yields, which includes tactical warheads as well as ICBM warheads of the *Polaris* and *Minuteman* class.

DOD has also requested the Atomic Energy Commission to come up with specifications for a 60-megaton warhead that could be carried by the B-52. In revealing this, former AEC Commissioner Leland J. Haworth said this request is "more than just expressing an interest."

Industry Favors ARPA Study

Industry representatives have told a Congressional subcommittee that the Advanced Research Projects Agency's (ARPA) chemistry office, which has been investigating high-energy chemical propellants, is being disbanded "prematurely."

R. A. Carpenter, manager of Callery Chemical Corp.'s Washington office, said that the ARPA program should have been extended to the propellant application phase. ARPA is now in the process of turning over the program to the services (see pp. 35, 131). Now the challenge must pass to NASA, Carpenter indicated.

The Callery Chemical Corp. spokesman was one among a host of industry witnesses who urged the NASA Legislative Oversight subcommittee of the House Space Committee to boost the government effort in the propulsion field.

Aerojet-General's vice president, Dr. W. R. Kirchner, told the subcommittee, which is chaired by Rep. Olin Teague (D-Tex.), that the M-1 engine funding should be doubled (see p. 16). This way the engine could become available for use by 1968, he said. NASA officials testifying on the Hill during various hearings described the M-1 as progressing at a "minimal" rate because of present funding.

Dr. Harold W. Ritchey of Thiokol Chemical Corp., recommended that NASA engage in an $80 million project, aimed at developing a 25,000-lb.-thrust engine using oxygen difluorides with other fuels. A $5-million investment in 10,000-lb.-thrust chamber work would get this program started in FY 1965, he said.

Ritchey also stressed the importance of the 260-in.-dia. solid rocket engine, which as yet has little commitment beyond the first phase. A total of from $122 to $142 million would bring the program up to flight status with manned rating, he estimated.

North American Aviation's Samuel K. Hoffman, president of the Rocketdyne Division, also testified in favor of expanding NASA's effort in both solid and liquid propellants.

Gilpatric On Defense Future

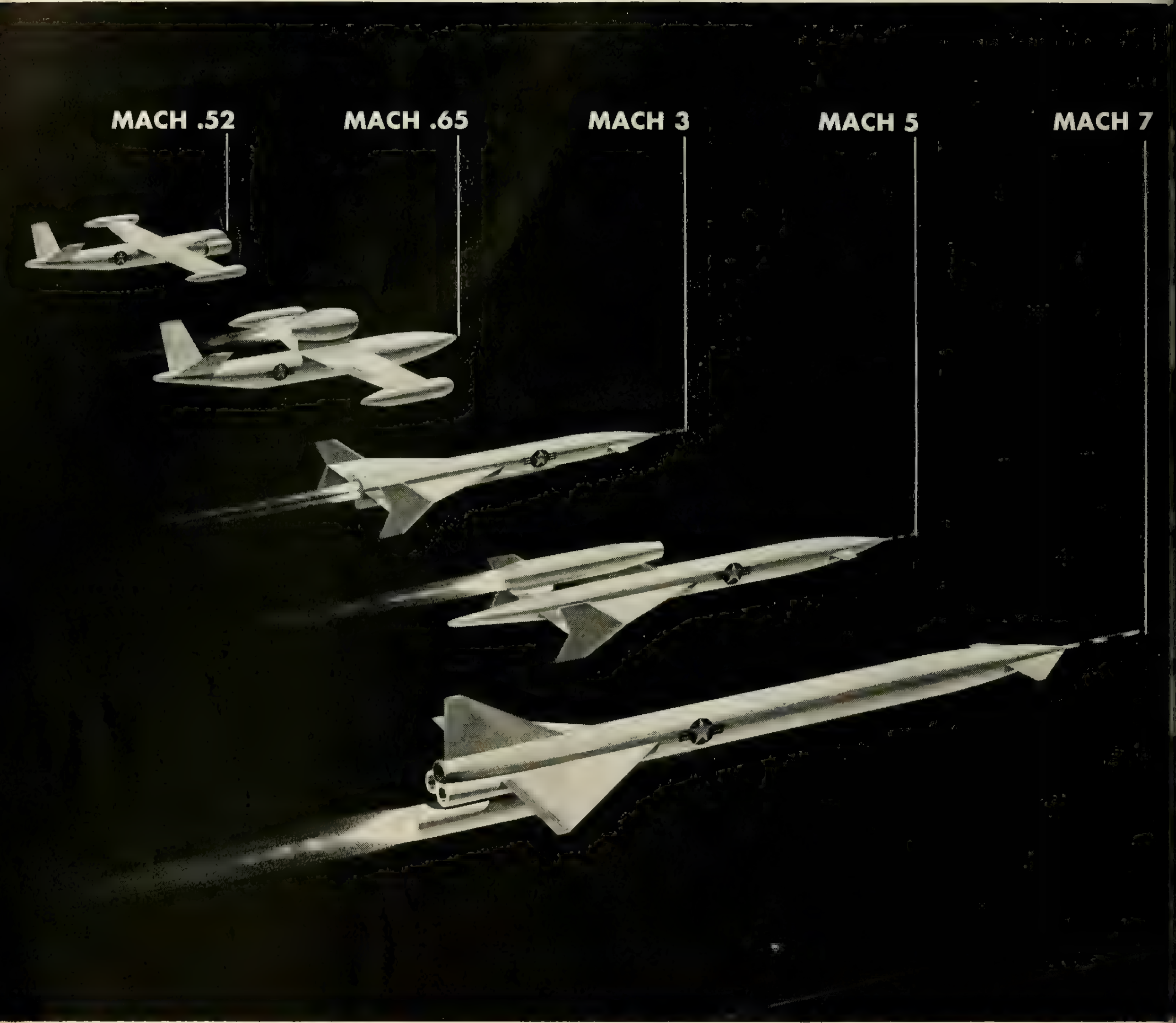
A blueprint for the defense posture of the United States—"provided the present movement toward détente within the USSR continues to progress in the years ahead"—was outlined by former Deputy Secretary of Defense Roswell S. Gilpatric in the April issue of the quarterly *Foreign Affairs*.

Discussing "the kind of military establishment which might be appropriate for the United States should there develop a continued easing of the level of East-West tension such as we have seen during the past year," Gilpatric gave this outline of the future force structure:

—*Strategic retaliatory forces:* a force consisting only of hardened and dispersed land-based and mobile sea-based missiles, with all the vulnerable, earlier-generation missiles deactivated and all manned bombers retired from active deployment.

—*Continental air and missile de-*

Beech "Imaginuity" in missile systems



Now, what's beyond Mach 7?

Beech "Imaginuity" in missile target systems is finding out

How fast will tomorrow's missile target systems need to be? The answer: just as fast as the speediest enemy hardware—jets or missiles—that Free World gunners may have to shoot at. What will it take to provide these advanced missile systems . . . to turn "impossible" requirements into solid reality by the time they are needed?

Beech "Imaginuity" is already at work, seeking—and finding—the answers. The Beech AQM-37A (KD2B-1), now in line production for the U. S. Navy, is capable today of speeds above Mach 3 and can be flown at altitudes of 90,000 feet. It gives today's most advanced weapon systems a realistic challenge to their capabilities.

But, just as important, Beech has already designed a family of missile target systems for a wide variety of defense training missions, ranging from Mach .52 to Mach 7—and is now reaching out beyond that.

This kind of probing into the future, plus Beech "Imaginuity" in design, development, fabrication and testing has given Beech a head start on development of the advanced missile systems that will be needed for tomorrow's training and air defense requirements.

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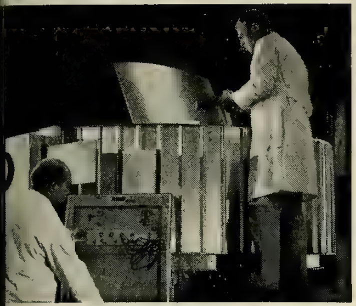

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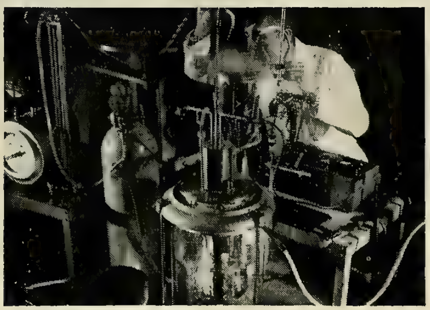
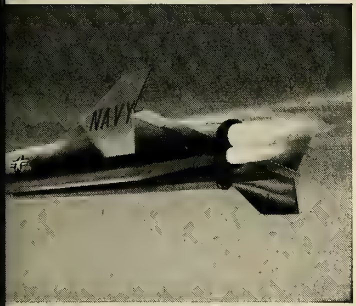


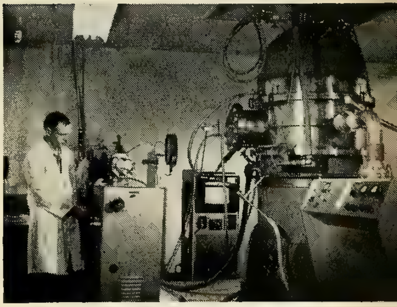
Propulsion...

Auxiliary Power...

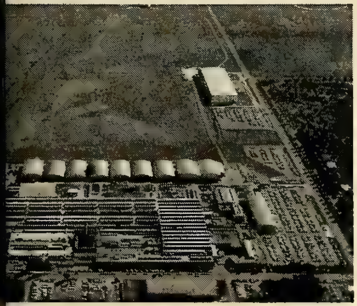


issile Target Systems

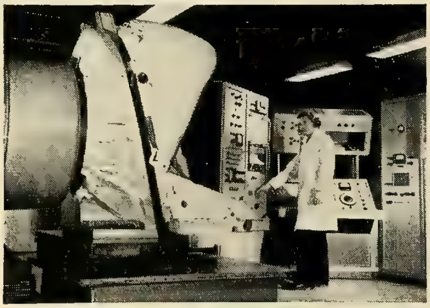
Manufacturing...



Space Simulation...



Facilities...



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fense forces: only warning systems, such as the big ballistic missile detection and tracting radars in Alaska, Greenland and Scotland, and the current generation of surface-to-air missile systems for tactical deployment would be maintained. . . . "There would be no production or deployment of anti-ballistic-missile systems in the absence of Soviet moves to proceed beyond experimental installations of such systems."

—*Reconnaissance forces:* "Both aircraft and satellite based reconnaissance systems would be retained and improved to take full advantage of state-of-the-art developments. . . ."

—*General-purpose forces:* "No significant changes would take place in this category except for a reduction of Army divisions that might be withdrawn at some stage from Korea or from Europe (if a decline in the Soviet threat allowed)."

—*Reserve and National Guard:* Reductions should be possible "retaining . . . only the high-priority divisions plus round-out units capable of quick call-up."

Such a force structure, the former secretary feels, would permit significant reductions in the defense budget. Gilpatric estimates these forces "should require an annual level of defense expenditure about 25% under the current (Fiscal Year '64) rate and 10% or so below that at the end of the Eisenhower administration." The FY '64 budget totalled $52.5 billion while the last Eisenhower budget (preliminary FY '62) stood at $44.7 billion. This would mean that DOD expenditures could level off at the $40-billion mark.

While operational forces would decline, Gilpatric emphasizes that "military research and development expenditures would remain high" to insure that no technological surprises would upset this balance of power. Savings in the RDT&E category would come primarily from the categories of Operational and Engineering Development.

"We would continue to put major effort into improvements in the command and control, reliability and flexibility of our strategic forces and would proceed with exploratory development of new systems." Final development and deployment of new systems, however, would depend on whether the Soviets aggressively push comparable systems.

Although Gilpatric is no longer No. 2 man in the Pentagon and throughout the article he stresses that his purpose "is not to lay out a plan for a military program at the end of the decade," his remarks cannot be dismissed lightly. While on active service in DOD, Gilpatric was in almost complete agreement with the ideas and policies of Secretary of Defense Robert S. McNamara.

Space Chamber Test Ending

Five men who have been confined for 30 days in a simulated space chamber at the Boeing Co. in Seattle are scheduled to emerge April 2.

No adverse effects have yet been reported in the run, in which a combination of physical, chemical and biological subsystems are being used for a complete life-support system (M/R Jan. 27 p. 28). This is the second attempt at a successful run; the first was aborted after five days last summer when the men became extremely nauseated.

National Aeronautics and Space Administration officials reported that all the kinks appear to have been worked out in the subsequent retooling of the system. Only minor modifications were made in materials.

The system uses a superoxide for oxygen regeneration and an activated sludge bacterial colony for waste processing.

Pakistan Begins Wind Studies

The Pakistan Space and Upper Atmosphere Research Committee (SUPARCO) has launched the first in a series of meteorological sounding rockets under a cooperative agreement with NASA.

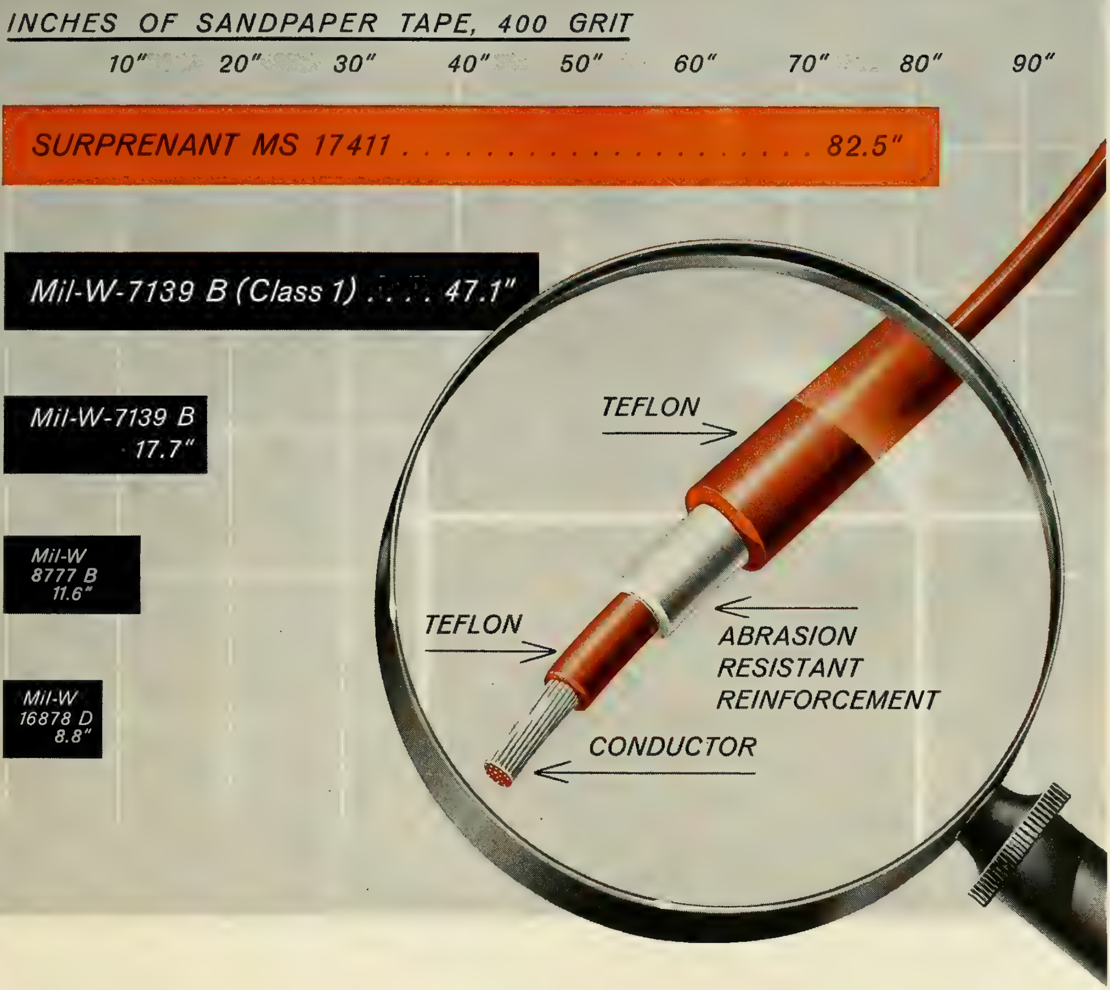
The launching was made Mar. 18 from Pakistan's Sonmiani Range near Karachi.

This is the first launching planned as a direct contribution to the International Indian Ocean Expedition (IIOE), a multinational effort by scientific groups to obtain and correlate information on oceanic and atmospheric conditions throughout the Indian Ocean Area. This area, which covers a seventh of the Earth's surface, remains largely unstudied.

The SUPARCO project is expected to provide significant data on the dynamics of air circulation at 100,000 to 200,000 ft. above West Pakistan's coast. The project will include at least 16 launchings.

CORRECTION

ON PP. 87 and 88 of this issue, the captions for the two photographs have been transposed. The laser beam is, of course, shown on p. 87; the pattern recognition device on p. 88.



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Abrasion resistant Teflon is a unique insulation developed by Surprenant with an ultra abrasion resistant material sandwiched between two layers of pure Teflon.

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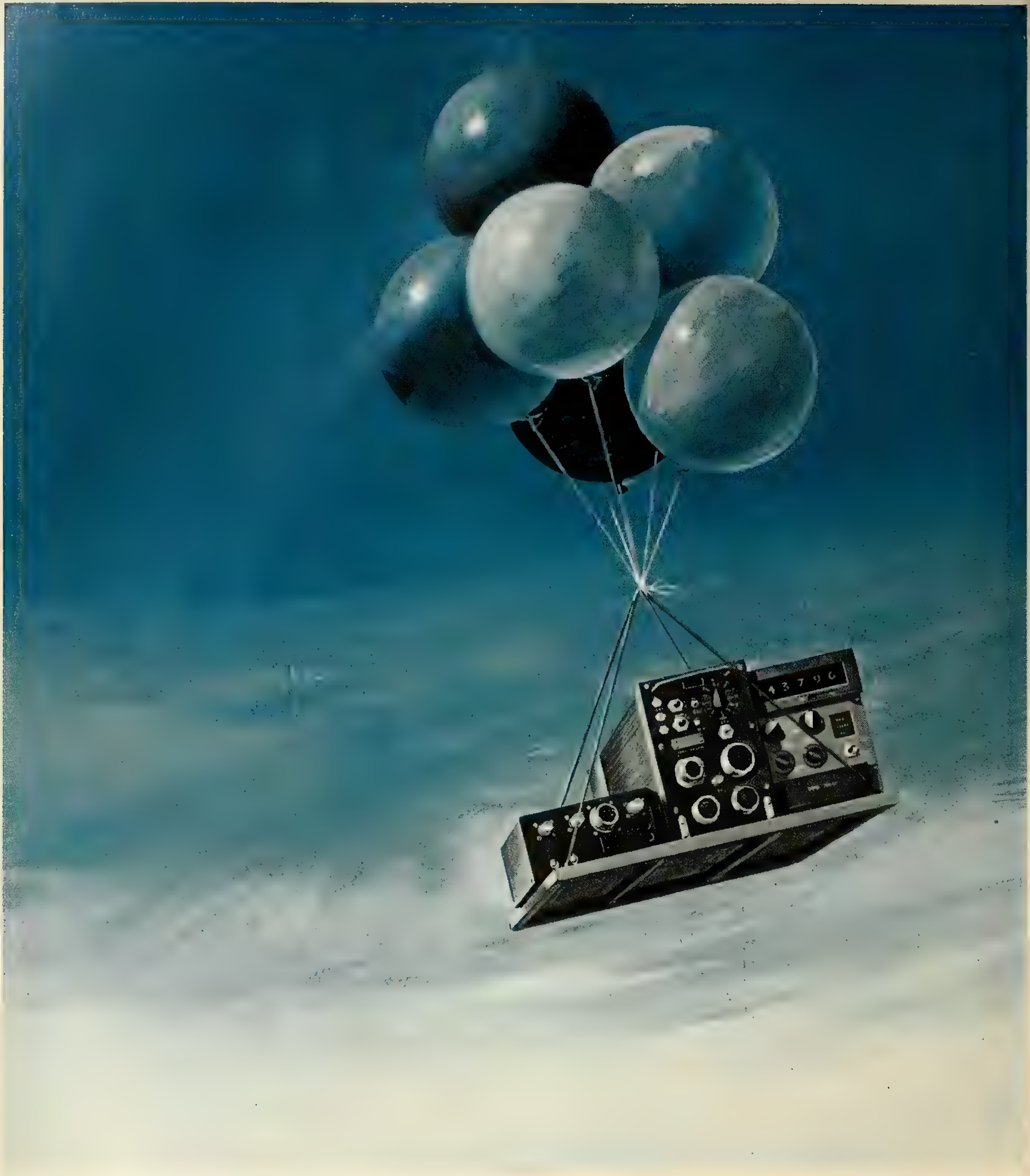

Now Loran-C travels light. Tiny silicon-wafer microcircuits—each containing up to forty components—are the heart of Sperry's AN/ARN-76 Airborne Loran-C Receiver. A hundred or more are mounted on plug-in cards...can quickly be inserted and withdrawn from the 19-pound system, which occupies only a half cubic foot of space. □ This first all solid-state Loran-C Receiver is less than one-third the weight and volume of existing systems, yet offers better than five times the reliability. Fully automatic, it has only five basic operator controls, as against more than twenty in Sperry's own previous system. Now under test by the United States Air Force, the AN/ARN-76 can be pilot-operated. Laboratory tests have indicated 1,500 hours mean-time-before-failure. For details, write: *INFORMATION & COMMUNICATIONS DIVISION, Sperry Gyroscope Company, Great Neck, New York.*

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Missiles and Rockets Volume XIV, Number 13 March 30, 1964

MILITARY SYSTEMS ISSUE

THE SURVIVAL of this nation depends on the maintenance of technological superiority over any potential aggressor. No organization has a greater influence over the development and application of this technology than does the Directorate of Defense Research and Engineering.

Under the Defense Reorganization Act of 1958, Congress has charged the Director of this agency with broad responsibilities and power. He is:

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—Supervisor of all research and engineering activities within DOD.

—Director of research and engineering activities that the Secretary of Defense deems to require centralized management.

Missiles and Rockets has examined the phenomenon that is DDR&E and in Part I details its organization and impact on both the military services and industry.

In Part II, the programs—representing some $7.5 billion of Defense spending—for which DDR&E has ultimate control are examined. This detailed analysis reveals new and significant changes in direction for future Defense R&E spending.

Part III covers the technologies upon which future weapons will be based and indicates the choices being made between competing ideas.

Office Overhauls R&D Rules; Tactical Weapons Now Biggest Market

Industry reassured that total research support will continue at high level; proof of technology must now precede development

A DIFFERENT ATMOSPHERE—In terms of both weapons system development and the rationale for such development—is being deliberately created by the Office of the Director of Defense Research and Engineering. This unquestionably will have a major impact on the defense industry, calling for significant modifications in the allocation of resources and efforts.

DDR&E officials stress, however, that the total level of DOD support for R&D will remain relatively constant. It would be a mistake, they say, for market planners to assume that a downward dip in this year's budget represents a trend.

In this new environment, future weapons systems will have to meet the stringent prerequisites outlined in the Project Definition Directive issued earlier this month (M/R, March 9, p. 14). Specifically, DDR&E insists that before a system development program is initiated the technology must be proven.

Component development and tests of critical or pacing subsystems will have to have been accomplished. Costs, schedule and reporting procedures will have been established. In other words, all major unknowns will have been eliminated, insofar as is possible, before development is approved. Concurrency, except in the rare case of preeminent national security interest, has been rejected as a method of development.

A second, no less major, change is that newness *per se* is not a criterion for development. The contribution of a proposed weapons system to overall national security must be clearly demonstrable, and it must be proven beyond dispute that that job cannot be done by a system already in the inventory.

Initially, the effect on industry of the current drop in R&D spending will be merely psychological, DDR&E officials feel. As long as the budget was going up, mistakes were taken care of and a "lousy" program or proposal was not particularly serious, one official points out; as the budget levels off, however, these mistakes become more serious. Industry attaches too much importance to the rate of increase of the budget, rather than the overall level of the Defense spending, this spokesman declares, and this gives rise to exaggerated fears.

A regrouping and redistribution of effort within the industry is foreseen as the number of major contracts diminishes. This should lead to a greater realization, and concern, with people—their skills and their positions within the organization. It is also likely that prime contractors will have to re-evaluate their subcontracting policies in order to maintain the necessary level of competence.

Finally, DDR&E officials are convinced that the efficiency of the industry will increase. Firms will concentrate on making profits on the contracts they have, rather than trying to get the next contract. These officials also anticipate a reduction in job-hopping within the industry, which will add to the competency and depth of experience of industrial organizations. "In the aggregate," one official says, "we expect good results from the leveling of Defense research spending."

- **Industry role grows**—DDR&E is extremely concerned with its communication with industry, conceding that this "has not been very good" in the past. Industry has been getting the wishes of the services, rather than the hard, definable directions that military technology is taking, one official states. For this reason, and because of the uncertainty of its own vision, DDR&E plans to hold a series of advanced planning briefings for industry this year (see box, p. 30).

Meanwhile, DDR&E expects that industry's role in the weapons acquisition process will be substantially enhanced. The first, and perhaps the most surprising, recommendation it has made in this connection is that industry should tell the military what it needs.

More specifically, DDR&E feels that defense-oriented firms are in a unique position to tell the services what the state of the art is and what, therefore, the military can reasonably ask for. "They can do this very well," one DDR&E official points out.

An example is the use of frozen versus irradiated food. The military may ask for a process that will allow food to be stored on the shelf for long periods of time. It is industry's responsibility, rather than just accepting this requirement, to tell the services that the technology can not support it, and to recommend a lesser, but still satisfactory substitute.

Another point made is that industry is literally the partner of project engineers against the budgeteers and, as

Program Package	Strategic Retaliatory Forces		
FY	'63	'64	'65
ARMY	....	.	.
NAVY	380.0	209.6	64.8
AIR FORCE	717.4	487.8	313.2
DEFENSE AGENCIES	. .	...	.
EMERGENCY FUND	....	.....	. .
TOTAL	**1,097.4**	**697.4**	**378.0**

* Reflects Congressional Action on Authorization Bill.

DR. HAROLD BROWN, Director of Defense Research and Engineering.

DR. EUGENE G. FUBINI, Assistant Secretary of Defense/Deputy DDR&E.

such, should promote tradeoff studies during development that would yield a weapons system and still stay within the time-cost envelope.

Initially, this would degrade the system; nevertheless, the weapon would be in the hands of troops and later models would bring it up to original performance specifications. *Polaris* is an example of how this was done effectively. *Mauler* is an instance in which it was not done at all.

Finally, the directorate says, industry should act as liaison between DDR&E and the services. This would ensure that the good ideas which are deserving of attention will not be lost at this interface.

- **Future needs**—High on the list of things that DDR&E rates as important are tactical warfare weapons, command and control, and needs generated by the diffusion of power throughout the world. The U.S., they contend, must "work harder in the area of less than all-out war." The possibility of escalation to thermonuclear war should not be dismissed, but certainly should receive less emphasis.

In restrospect, they feel that the money spent on strategic weapons was well spent, but that the tactical area has been underpaid. This will be remedied during the next several years.

A problem seriously concerning DOD is the diffusion of power—not only in the Sino-Soviet bloc but also in the Western alliance. One high-level DDR&E official notes that much of his time is being taken up by this problem. He says industry would do well to concentrate some of its technical efforts in this area.

Development of command and control, particularly in tactical systems, is also expected to intensify over the next several years. This is an area of deep concern and dissatisfaction within DDR&E. Even the major "L" systems are being revamped to remove their "systems" bias and to ensure that they present the commander with the amount and type of information he requires. There is greatly increased concentration on the "software" aspects of this problem.

Tactical weaponry is now the area of greatest potential for industry. A major re-emphasis is underway in this field; in the next few years billions of dollars will be spent to bring tactical weapons development up to the levels of effectiveness enjoyed in the strategic field.

This is not to say that these weapons will have a comparable level of sophistication. In fact, the stress will be on simplicity, reliability and ruggedness. These bromides from by-gone days, however, are being given new meaning through application of technology and analysis techniques developed over the last decade in the strategic field. The quantum improvement expected in tactical weapons and the enormous scope of this effort are detailed in the Tactical Programs story in this issue (see p. 54).

- **New life for Midwest**—This shift in DDR&E interest could mean new contracts for the Midwest and other areas of the nation which feel that they have been left out of the defense picture. However, although these types of weapons have in the past been produced with great success in the Midwest, that region must make considerable changes in outlook and approach in order to win the new tactical business.

These weapons, although adapted to long production runs, will be inseparably wedded to advanced technology. This requires a strong industrial base closely associated with the scientific community—something which already exists in industries associated with ballistic missile technology but must be created through a concerted effort in more traditional, less defense-oriented industry.

Initially, the Dept. of Defense will be concerned with a basic understanding of the environment within which tactical forces must work—how can this environment be made to work for us,

EARCH, DEVELOPMENT TEST & EVALUATION BUDGET PROGRAM

Continental Air and Defense Forces			General Purpose Forces			Airlift & Sealift Forces			Reserve & Guard Forces			Research & Development			General Support			TOTAL OBLIGATIONAL AUTHORITY (TOA)		
'63	'64	'65	'63	'64	'65	'63	'64	'65	'63	'64	'65	'63	'64	'65	'63	'64	'65	'63	'64	'65
0.8	9.6	2.3	106.3	78.7	29.6	....	....	....	....	....	....	1,177.5	1,314.0	1,341.1	1.9	20.4	24.1	1,286.5	1,422.7	1,397.0
3.0	4.4	2.0	168.3	276.6	269.5	...	....	....	....	1.0	2.1	921.7	1,040.4	1,098.8	4.5	12.9	13.7	1,477.5	1,545.0	1,451.0
27.5	35.4	14.0	120.0	233.2	324.9	69.6	15.0	9.4	...		...	2,501.5	2,208.1	2,081.4	470.4	645.8	517.1	3,906.4	3,625.3	3,260.0
...	...	..	....	..	...	....	....	....	..	..	.	250.0	278.4	294.8	197.9	161.5	224.2	447.9	439.9	519.0
....	....	....	....	....	....	....	....	....	....	....	....	120.4	101.0	150.0	....	...	...	120.4	101.0	150.0
31.3	**49.4**	**18.3**	**394.6**	**588.5**	**624.0**	**69.6**	**15.0**	....	....	**1.0**	**2.1**	**4,971.1**	**4,942.0**	**4,966.1**	**674.7**	**840.6**	**779.1**	**7,238.7**	**7,133.9**	**6,777.0**
GRAND TOTAL DEFENSE R&D (INCLUDING PERS., O&M, PROC., MIL CONST.)																		**7,739.0**	**7,602.2**	**7,088.7***

rather than how do we overcome the environment?

In the area of weapons, there is general dissatisfaction with ground-air systems and their interrelationships, antitank weapons which leave the gunner exposed while the weapon closes on the target, inadequate target-acquisition capabilities of tactical forces, lack of new and unique weapons with delivery systems of such accuracy that high-explosive can be substituted for nuclear warheads, and the absence of special equipment designed for specific areas of the world rather than all areas.

- **DDR&E reorganization**—On March 1, DDR&E completed a reorganization which regrouped the various programs under five deputy directors: Strategic and Defense Systems, Tactical Warfare Programs, Administration and Management, Research and Technology, and Space. The Special Assistant for Command and Control was retained, and Intelligence and Reconnaissance was moved from what used to be called Research and Information Systems to the status of a Special Assistant.

Other shifts included the creation of a Plans and Policy office under Administration and Management, establishment of an Assistant Director for Technical Support of the National Military Command System and Strategic Command and Control under the Deputy Director for Strategic and Defensive Systems, and relegation of the Deputy Director of Engineering and Chemistry to the status of an Assistant Director for Chemical Technology. Comparable shifts were made in other parts of the organization.

Under the new organization the strength of DDR&E is not substantially increased. There are positions for 180 professional civilians, compared with 164 previously, and 153 military, as opposed to 144 under the old concept. Clerical help, both civilian and military, totals 228; earlier it was set at 220. These figures include both the Advanced Research Projects Agency and the Weapons System Evaluation Group, which are under the control of Dr. Harold Brown, DDR&E Director.

- **How DDR&E works**—Although deputy directors have been named for each of the major areas of Defense R&E concern, projects are assigned on an individual basis rather than by any rigid adherence to an organization chart. Thus, a project such as the Military Communications satellite falls under the purview of the Assistant Director for Communications and Electronics rather than the Deputy Director for Space.

DDR&E tends to work informally. There are frequent meetings with service counterparts and working drafts of memoranda are prepared by the services so that once the language is fully worked out, the paper can be sent to DDR&E with full assurance that it will be accepted.

This, according to one military officer, speeds up the process considerably and is in marked contrast to pre-Brown DDR&E. In those days, the services would submit a paper only to have it bounce back for some minor change in language; there was no assurance that once this was corrected the correspondence would not be returned again.

Since DDR&E cannot control the military R&D effort in detail, it is trying to control the environment within which that program must work. In effect, the goal is to set up clear-cut procedures within which the services can make decisions. By periodic program reviews, the overall content of the R&D effort can be controlled. "We would like to give the services a free hand to make these decisions," one top DDR&E official says, "providing they meet certain content requirements and management procedures."

- **Control procedures**—Under the Hitch Programming system there are two major reviews of the R&D program each year. The first is the submission of the program and supporting information for the coming year's budget. This normally takes place in late summer and early fall. The next total program review takes place after Congress acts on the RDT&E program; it requires the services to support their requested allocations of funds before they are released.

The DDR&E staff reviews these program plans and the funding requested and recommends action to Brown, who in turn makes recommendations to the Secretary of Defense.

Through change proposals, review of technical development plans and liaison with the military services and its contractors, the DDR&E staff maintains continuous review of the R&D program. Over 150 change proposals were submitted to DDR&E last year, and these required action ranging from approval of minor modifications of an existing program to approval of a complete change in direction of a weapons system development.

Brown said in recent Congressional testimony that he and his office attempt "to separate out those areas in which I am an expert, or supposed to be an expert; namely, the technical research, engineering, R&D and scientific areas

Response Taxes Briefing Facilities

RESPONSE TO DOD'S announcement that 13 advanced planning briefings would be held for industry beginning in May has been so enthusiastic that DDR&E has a problem in accommodating those who want to attend.

Topics, date and host for the first seven briefings are:

Aircraft	May 25	Air Force
Missiles	May 26	Air Force
Electronics	May 27	Navy
Command and Control	Last week of May or in June	DDR&E
Arms and Ammunition	2nd Week of June	Army
Chemicals and Biologicals	June 15	Army
Nuclear Products	June 29	Navy

All the briefings except Arms and Ammunition, which will be held in Chicago, will be in Washington, D.C.

- **Attendance procedure**—Not more than three persons from each industrial organization will be permitted to attend —in fact, some consideration is being given to cutting this to one, to accommodate all the respondents. Only officials serving at the chief executive officer, board chairman or senior planning level will be considered.

Thirty to 60 days in advance of the briefing, a company should furnish the briefing host the names, titles and security clearances of persons wishing to attend a particular briefing.

Addresses of the briefing hosts are:

—Army: Lt. Col. Ernest H. Trussell, Technical and Industrial Liaison Office, Army Materiel Command, Room 2748, Gravelly Point, Washington, D.C. 20315. Telephone: (Area Code 202) OXford 7-4948.

—Navy: Capt. William W. Jones, Office of Naval Material (Mat 32), Room 2020, Main Navy Bldg., Washington, D.C. 20360. Telephone: (Area Code 202) OXford 6-5125.

—Air Force: Col. Robert F. Todd, Office of Deputy Chief of Staff (Plans), Air Force Systems Command, Andrews Air Force Base, Washington, D.C. 20331. Telephone: (Area Code 301) 981-9111, Ext. 5309.

—DDR&E: Maj. John Delistraty, USA, Office of the Director of Defense Research and Engineering, Plans and Policy, Room 3 E 1082, The Pentagon, Washington, D.C. 20301. Telephone: (Area Code 202) OXford 7-8251.

from those areas in which I am not." In other words, DDR&E does not attempt to say whether a system should be deployed or whether it is operationally effective. It determines only whether it is technically feasible and can be developed within the time and cost estimates of the services.

It should be stressed that, apart from ARPA, Brown has no line authority over the R&D efforts of the services. His is primarily a staff function of recommending courses of action to the Secretary of Defense. However, his influence, both in this role and in actions delegated to him by the Secretary of Defense, is not inconsiderable.

• **Problems in-house**—A continuing headache within DDR&E is the quality of in-house support. Although DDR&E feels that it has "turned the corner and at least they're not getting any worse," in the words of one spokesman, the quality is so widely variable that it is hard to apply across-the-board rules to these institutions.

Studies are continuing to identify the conditions which have made such labs as the Naval Ordnance Test Station so outstanding. The hope is that general principles can be developed to apply to all the labs.

Another frustration is the lack of imagination and ingenuity evidenced in-house. Right now, DDR&E is trying to find a lab to which it can assign a major project—development of a high-power laser—as part of its program to upgrade the quality of work performed in-house. Its main difficulty, however, is finding a research lab willing to risk the undertaking. ■

Brown Wants More Ingenuity in DOD Research

DDR&E's Defense Science Board—the senior technical advisory body in the Department of Defense—has been asked by Dr. Harold Brown to undertake a review of research policies within the Department.

The wide-ranging study will include a general assessment of the effectiveness of Defense research policies and an exploration of means to improve the management of research programs so that more invention and ingenuity is injected into the Department's research—particularly in the research and exploratory development areas. Also, the board is to make recommendations on the improvement of in-house laboratories, with emphasis on increasing the productivity of technical personnel.

This assignment is typical of the work conducted by DSB's experienced educators and industrialists. Presently chaired by Dr. Frederick Seitz, the board has also studied:

—The problem of collection, storage and retrieval of scientific information within the Defense establishment. Its report was instrumental in the establishment of an Asst. Director of Technical Information at DDR&E level and a consequent overhaul of the scientific information program.

—The extent and scope of the ballistic missile defense program, to reassure DOD that everything that could be done was being done.

—Organization of the DOD behavioral sciences program, as well as the level of effort being supported in this field. This led to the establishment in ARPA of an Information Processing and Behavioral Sciences group. The board plans a follow-up study in this area as one of its future items of business.

• **How it operates**—In general, the board conducts its work by subcommittees. These may consist of one or more members of the group, assisted by professional people within DDR&E. The group leader may also decide to draw on the resources of his own organization to conduct a particular study. Only full-time staff member for the DSB is William W. Hammerschmidt, Executive Secretary to the Board.

Board reports made to Secretary McNamara through Brown are not accepted uncritically. It appears that the more specific a study is dealing with a weapons system, the less impact it has. It is in the policy and planning guidance areas that the board has its greatest effect.

Typically, the entire Science Board meets three times each year with executive committee meetings every two months. Brown usually attends these meetings when time and the press of business permit.

The board was created in 1956 following recommendations made by the Hoover Commission, which felt that DOD should avail itself of the best technical brains in the nation while, at the same time, giving the scientific community a direct channel into the Defense establishment.

Presently, the composition of the Defense Science Board is loaded in favor of aeronautics, astronautics, nuclear technology and physics, although an attempt is being made to broaden the board's experience. Appointments to the DSB, usually of three or four years duration, are made by the Secretary of Defense upon the recommendation of the Director, Defense Research and Engineering, and the concurrence of the Chairman of the Defense Science Board.

• **DSB membership**—In addition to Dr. Seitz, the Defense Science Board includes some of the best-known scientists and industrialists in the nation: Daniel Alpert, Director of the Coördinated Science Lab, University of Illinois; Thomas E. Caywood; Clifford C. Furnas, Chancellor of the University of Buffalo; Edward H. Heinemann, Vice President (Engineering), General Dynamics Corp.; Harold A. Wheeler, President, Wheeler Labs Inc. These members' terms expire in 1964.

Also on the board, with terms expiring in 1965, are: Walter H. Brattain, Nobel-prize-winning physicist at Bell Telephone Labs; Leo Goldberg, Higgins Professor of Astronomy, Harvard University; Lyle H. Lanier, Executive Vice President and Provost, University of Illinois; Allen E. Puckett, Vice President and Assistant Group Executive (Aerospace Group), Hughes Aircraft Co.; Lloyd P. Smith, General Operations Manager (Research Operations), Aeroneutronic Div. of Philco Corp.

Sitting on the board until 1966 are: Patrick E. Haggerty, President and Director, Texas Instruments; William G. McMillan, Chairman, Chemistry Dept., University of California at Los Angeles; Thomas L. Phillips, Executive Vice President Raytheon Co.; Ernst Weber, former president of Brooklyn Polytechnique Institute, now a consultant.

Newly named members of the board for a term ending in 1967 are: David T. Griggs, Professor, Institute of Geophysics and Planetary Physics, UCLA; Gerald M. McDonnel, Department of Radiology, UCLA; L. Eugene Root, President, Lockheed Missiles and Space Co.; and Kenneth M. Watson, Physics Department, University of California (Berkeley).

Ex officio members include: Allen V. Astin, Director, Bureau of Standards; Manson Benedict, Chairman, General Advisory Committee, Atomic Energy Commission; Hugh L. Dryden, Deputy Administrator, NASA; Leland J. Haworth, Director, National Science Foundation; Morrough P. O'Brien, Chairman, Army Scientific Advisory Panel; Dr. Seitz; H. Guyford Stever, Chairman, Air Force Scientific Advisory Board; and Eric A. Walker, Chairman, Naval Research Advisory Committee. ■

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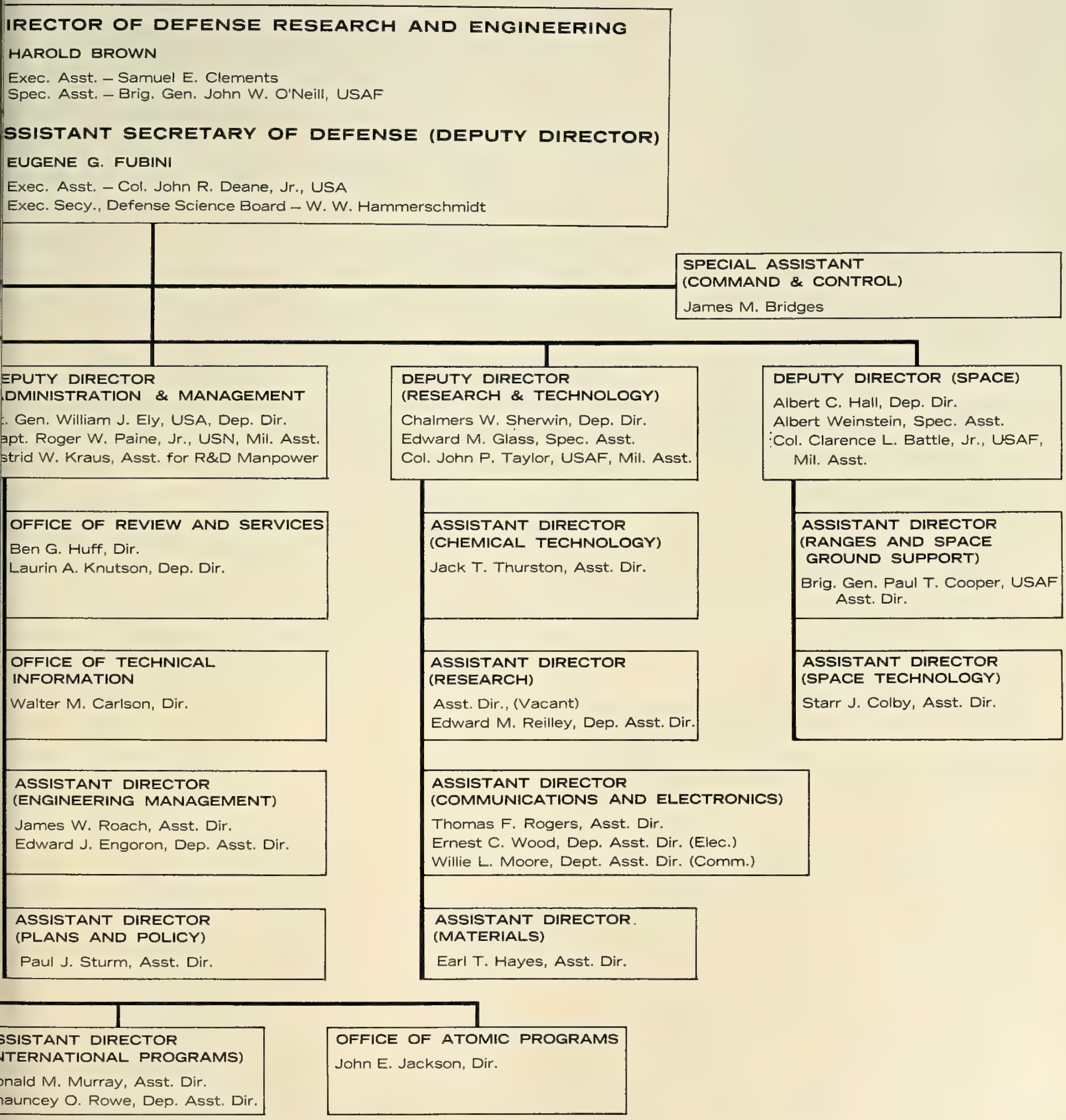

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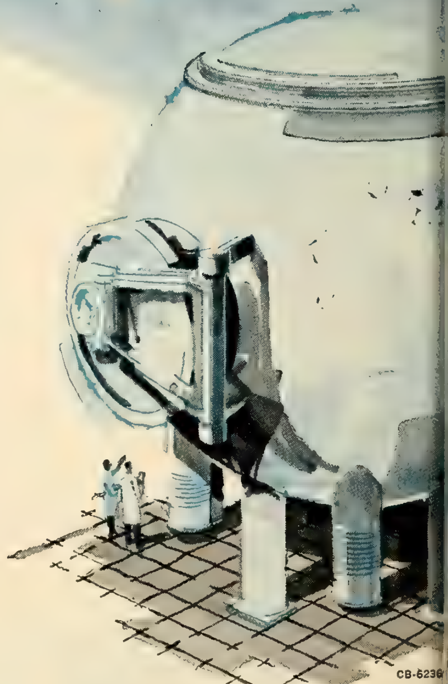

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ARPA Ending Two Programs

Agency transferring propellant chemistry and energy conversion programs to services to make room for new work; new trend is to bring basic, applied research closer together

DR. ROBERT L. SPROULL, Director, Advanced Research Projects Agency.

THE ADVANCED RESEARCH PROJECTS AGENCY is about to shed two of its programs sometime this year, but generally has reached a period of stability with a budget of nearly $300 million a year.

The projects it is transferring are:

—Propellant chemistry. ARPA has reached the theoretical limits in a number of propellants, both solids and storable liquids. According to ARPA director Dr. Robert L. Sproull, the next step is to harvest this information for practical use. This work is being divided up among the individual military services.

—Energy conversion. This program included a look at fuel cells, magnetohydrodynamics, thermo-chemistry, and the like, for possible ground and satellite use. These also will be divided up among the services according to their development needs by the end of FY '65.

ARPA's other programs—ballistic missile defense (Defender), nuclear test detection (*Vela*), materials (Pontus), remote area conflict (Agile), behaviorial sciences and information processing—will probably remain with the agency for several years, although there are constant changes within the programs themselves.

According to Sproull, ARPA has reached a stage where it must shuck off programs if it is to take on new ones, or the character of the agency would change.

ARPA celebrated its seventh year of existence this February, but the adult looks very little like the infant. The agency, which once handled DOD's space programs and was very hardware-oriented, has turned into a rather scholarly organization, which brings a somewhat more basic research apporach to most of the vital defense questions facing the country.

Says director Sproull: "Our role is as a go-between between the laboratories, universities, and better industry on one hand, and with defense problems on the other."

- **DDR&E relationship**—Tasks are usually assigned this agency when they require top priority, top talent, quick reaction time, and when impartiality is particularly needed. Most assignments to ARPA are made by Dr. Harold Brown or by Secretary Robert S. McNamara through Dr. Brown. However, the suggestion for at least one program (materials) has come from ARPA itself, and a great deal of latitude is given project directors once the assignment is made.

However, when budget time comes around, ARPA apparently gets little favoritism in spite of a close relationship with DDR&E. "ARPA budgets have been cut at about the same rate as service RDT&E budgets," spokesmen say.

And when the budget is submitted to Congress and cuts are made, ARPA does not necessarily get preferential treatment during reprogramming actions in DOD. The exception to this, of course, is when Congress specifies that a certain item shall not bear any of the reduction, as in Project Defender last year.

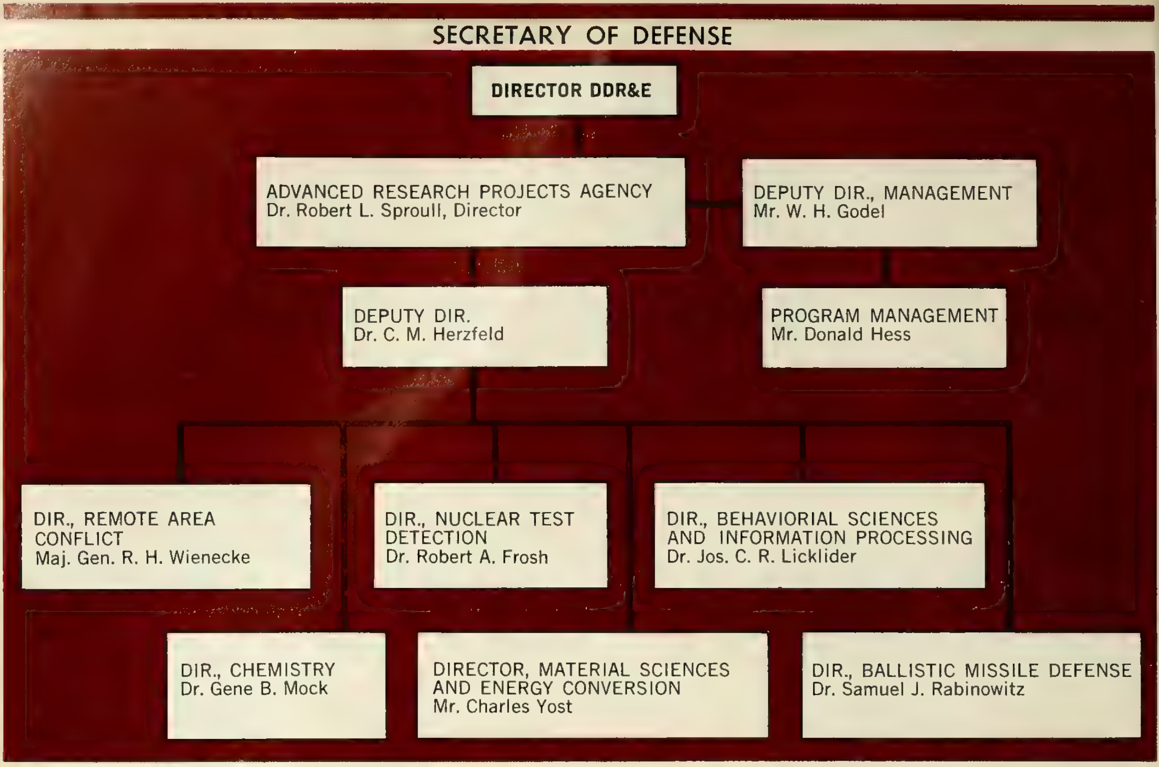
- **Sproull influence**—A new trend in ARPA since the arrival of Dr. Sproull from Cornell University has been to bring basic and applied research closer together.

Sproull's innovation is to try to create a small core—perhaps 5%—of basic research in each applied program, and vice versa. If this appears to be worthwhile, the director said, ARPA may set up a longer range program, probably using non-profit groups of in-house laboratories working with universities.

- **Contracting**—"Every time things go slowly, someone suggests that ARPA do its own contracting," Sproull says. As it now stands, ARPA relies upon military service "agents"—elements such as laboratories—to carry out contracting and monitoring services.

According to ARPA program manager D. K. Hess, agents are chosen at the lowest echelon that can handle the work—such as the Naval Research Laboratory or Ordnance Laboratory, rather than the office of the Secretary of the Navy. Choice is based upon similarity of work or related programs, technical competance, facilities, or simply because the particular group does not have a bias, if there is some competition among the services for a particular project.

ARPA probably won't change this contracting procedure for several reasons, Sproull says. First, it would require enlarging the staff—a move which he has vigorously avoided. In addition,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Mr. W. H. Godel
DEPUTY DIR.
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PROGRAM MANAGEMENT
Mr. Donald Hess
DIR., REMOTE AREA CONFLICT
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DIR., CHEMISTRY
Dr. Gene B. Mock
DIRECTOR, MATERIAL SCIENCES AND ENERGY CONVERSION
Mr. Charles Yost
DIR., BALLISTIC MISSILE DEFENSE
Dr. Samuel J. Rabinowitz

the agency "has a great deal to be gained by the services handling the contracting. When the project is ready to be transferred, the competence has been instilled in the service."

Also, he adds, if the service is doing similar work, it forces a closer relationship. "Otherwise, it would be easy to bypass the other group," the director pointed out.

A few contracts, such as Rand and other "think-factory" studies, are put through the Office of the Secretary of Defense, but there is no technical monitoring capability in that office.

The contracting policy has not harmed the agency, ARPA spokesmen say. ARPA has DX priority for Project Defender (for more Defender details, see p. 59). Other projects have a certain built-in priority because they come from the DOD level.

Current contract awards are running, in money value, at about 60% to industry, 40% to universities or non-profit organizations, spokesmen say. In actual number of awards, however, the university contracts predominate, since the research projects are of lower dollar value.

• **Scientific staff sought**—Sproull says that in general he looks for scientific talent of a specific nature, except when a broader base is called for such as in Project Agile, a geographic and ethnic survey of Viet Nam.

This leads to some problems when the project is completed. For instance, in the chemical propellant program ARPA had at least four-top-grade chemists who had to be released. The agency tries to see that they get jobs in other DOD facets, if possible.

At least one, however, will go with the propellant project when it is turned over to the services, a practice that might be continued in other cases, Sproull indicated.

The director admitted that, as with all government agencies, there is some difficulty in trying to compete with the higher salaries and other benefits offered on the outside. However, he said that by pointing out to the scientific community that ARPA must have first rate staff or the whole country will suffer, he has been able to get the kind of staff he needs.

There are 73 professionals now in ARPA, five of whom work in a program management office assisting the technical directors. This management group handles contracting arrangements, budgeting, security, planning, liaison between the services and ARPA, Congressional liaison, public affairs and technical information, and other administrative matters.

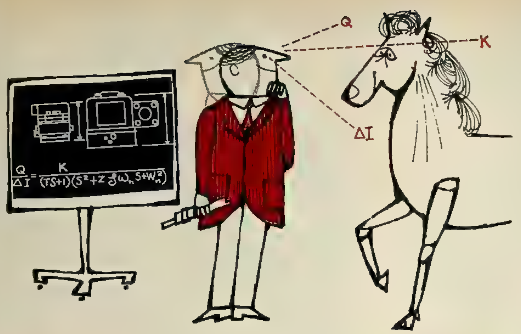
Although a move was underway just before Sproull's arrival as director last year to create a director's staff, Sproull terminated these plans. The only management change he has made is to create the post of permanent deputy director, which is held by Dr. Charles M. Herzfeld, who is equally able to speak for ARPA as the director, Sproull said.

The rest of the staff has remained about the same size since the new director has taken charge, except for an increase of four persons in Project Agile. This has reflected a shift in emphasis from the "quick fix" kind of operation to a basic research project.

• **Who influences**—After DDR&E, ARPA is perhaps most directly affected by the President's Scientific Advisory Committee (PSAC). The propellant chemistry project largely grew out of PSAC suggestion.

An ARPA member attends all meetings of the Defense Sciences Board, and always "treats their recommendations seriously, but does not necessarily make changes." DSB was instrumental in the creation of ARPA, (see p. 31).

Another group with some influence is a committee of young scientists called Jason (p. 39). According to Sproull, this group has become very stimulating to ARPA because of the members' critical approach and young ideas. In several cases, JASON members pitched in and worked on ARPA problems. Primarily, however, the group acts as an idea and evaluation panel. ■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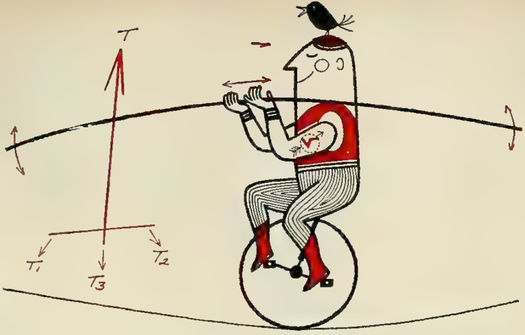

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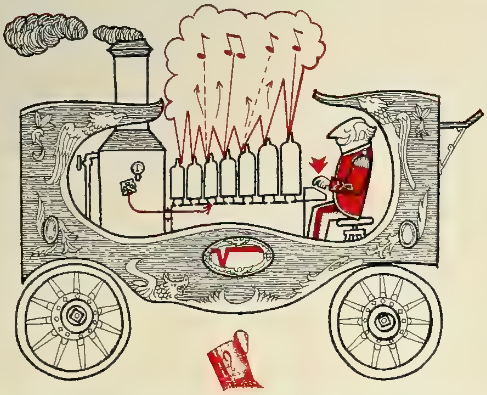

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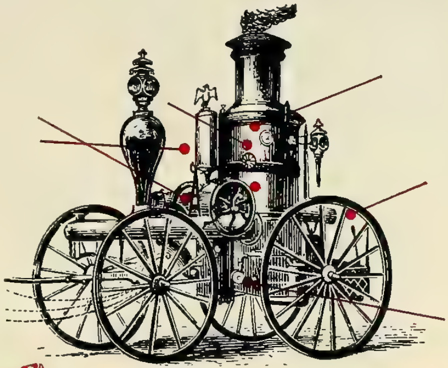

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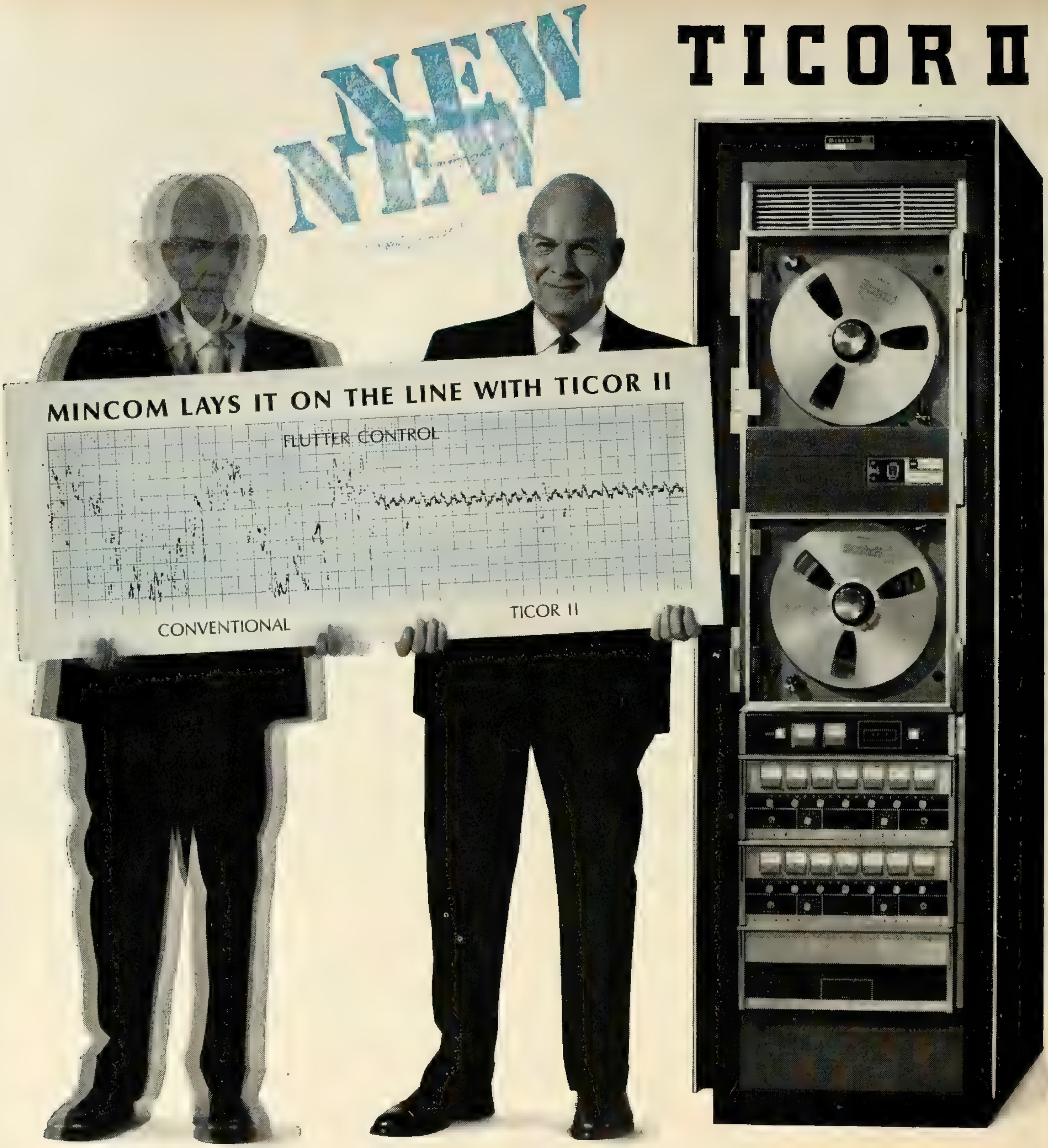

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Military Not Content with Role in WSEG

Despite friction, WSEG and IDA have made notable contributions in vital defense studies; have excellent capabilities and occupy key organization positions

UNFORTUNATELY, the most noteworthy aspect of the Weapons System Evaluation Group (WSEG) is the continued dissatisfaction of its military hierarchy with the role it has been assigned.

This dissatisfaction, which flared into the open in January, 1963, has led directly to the retirement of one WSEG director and appears to have been the most probable cause of a second man leaving the post. It is regrettable that this obscures the outstanding contributions the group has made to the present defense posture.

The "delicate situation," as one DDR&E official terms it, results from the fact that the contractor, the Institute for Defense Analyses (IDA), has to be responsible for a product. "Congress wouldn't look kindly on us just hiring warm bodies," is the way this official puts it.

However, the military group in WSEG must take responsibility for something, and the difficulty is in seeing that the appropriate people have something identifiable in the WSEG/IDA reports.

There is unanimous agreement that WSEG is too valuable an organization to be allowed to go by the boards. Since IDA was formed in 1956 to work as an integral part of WSEG, the organization has made strategic studies and trade-off analyses which have constituted important contributions to the present defense posture.

"Take any issue of major importance over the past couple of years," one official says, "and you can be assured that WSEG has been involved." In fact, WSEG officials display pique—natural to people who feel that they are doing good work but, because of the nature of that work, not getting recognition—that the Rand Corp. has gotten credit for policy changes that resulted from WSEG work. They admit that Rand has, of course, studied these things, but they say "it is a lack of correct emphasis" to give them sole credit. Among the more important areas, WSEG has studied and claims some credit for:

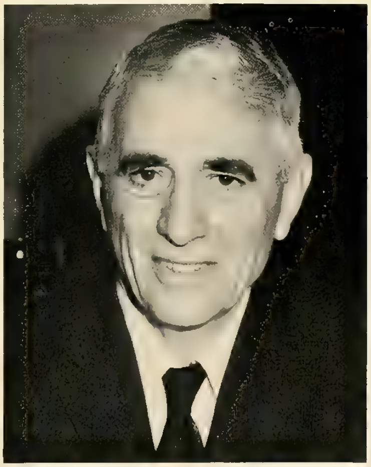
—The size, nature and composition of carrier forces.

—Necessity for, and nature of, "options" in the application of military power.

—Problems of less than total war (an area in which recommendations were made to beef up counter-insurgency forces and capabilities in 1959).

—Much of the "new look" in defense strategy and posture.

MAJ. GEN. JOHN RUGGLES, acting Director, WSEG.



DR. BERNARD O. KOOPMAN, Director of WSED.

- **WSEG unique**—The importance of WSEG lies in its unique combination of experienced military officers working next to experienced academicians within the Dept. of Defense. This combination exists nowhere else in the country. Almost all operations research organizations have retired military officers on their staffs but this, in the opinion of Defense officials, is a poor substitute for active military men.

WSEG's position within the Defense establishment is a valuable asset also. In conducting a study, the group can call for—and get—information from any of the services or any of the Defense agencies. The services, in fact, will give information to WSEG that they will not give to one another.

Intellectually, the IDA group—more specifically the Weapons System Evaluation Division (WSED) of IDA—is an integral part of WSEG. It is co-located with the DOD organization and the two groups work side by side in many instances. Legally, WSED is one division of the Institute for Defense Analyses.

A lieutenant general heads WSEG and has three deputies of two-star rank

—one from each of the three services. The main reason for this much rank is to give WSEG a position of strength from which to deal with the services.

Under each of the deputies are 15 officers of colonel and Navy captain rank. These officers are assigned to various projects, usually two to a project, and work with the WSED staff.

Army Maj. Gen. John Ruggles is the acting Director of WSEG. A combat infantry officer and a former commander of the 1st Infantry Division, he has served as a Deputy Director for the past year and typifies the type of officer assigned to WSEG.

The WSED contingent is headed by Dr. Bernard O. Koopman, formerly of Columbia University. He has a professional staff of approximately 100. Most of these are full-time, semi-permanent staff personnel, but if the organization needs certain capabilities for a study it can draw, for a limited period of time, on high-level scientific personnel from the 11 universities which make up IDA.

- **How a study is conducted**—Although WSEG is under the surveillance and direction of the DDR&E chief, Dr. Harold Brown, its study requirements can come from DDR&E or the Joint Chiefs of Staff—or from the Secretary of Defense himself.

These studies vary in size and requirements, ranging from a rather brief month-long exercise to a continuing survey of a particular area, such as the state-of-the-art in lasers. Generally speaking, they involve system analyses and operations research into the merits of weapons systems or competing weapons with respect to operational use, relative costs, effectiveness and limitations.

Legally, once a study requirement has been given to WSEG the Director must write a Task Order to the President of IDA, requesting WSED to undertake the study. The parent corporation instructs WSED to conduct the study. From that point, a project leader from WSED is designated and assembles his team, including two military officers assigned by WSEG.

Once the study has been completed, a report is written and transmitted to the Director of WSEG. The report is clearly labelled as an IDA document which, due to the close working relationship of WSEG and WSED, is somewhat of a misnomer.

The Director of WSEG can add his comments to the report if he feels it necessary—and this is another source of irritation. Since there is a constant cross-feed between WSEG and WSED during the study, the Director, as a practical matter, most of the time need only forward the report to the requesting agency.

Both the Director of WSEG and the Director of WSED can conduct studies on their own initiative—in the case of the latter it is part of his overhead. But again, as a practical matter, this prerogative has not been exercised. The volume of studies which the organizations are asked to undertake is so large that priorities often have to be requested from the originating agency.

One of the main rewards of working for WSEG/WSED is that the papers, studies and verbal information the organization is asked to prepare is transmitted quickly to the top levels of the Defense establishment—and carries considerable authority.

Quite candidly, however, some of the officials involved admit that while the civilian/military group does an admirable job of collecting the data on which to make an analysis, it is somewhat weak on the analysis itself. A very real effort is being made within the group to strengthen the analysis sections of the reports.

Regarding acceptance of WSEG reports at the initiating levels of DOD, officials concede that although the DOD hierarchy initially was very receptive to the WSEG work, it has since become more critical. Part of the reason, they say, is that more groups within DOD are doing effectiveness studies.

- **WSEG: the genesis**—Although Operations Research was active prior to World War II, it was not until the war that it really proved effective. James Forrestal, the first Secretary of Defense, found that he was presented with problems the military wasn't qualified to solve—primarily in the fields of applying technology to military problems. To insure a capability for impartial evaluation of weapons systems, he created in December, 1948, the Weapons System Evaluation Group.

The problem then became one of how to include the scientific knowledge required. Civil Service proved inadequate to the task. For a time the Massachusetts Institute of Technology assumed the responsibility for recruiting the requisite scientific talent. However, MIT felt that the task was not one for a university and, as a consequence, the Institute for Defense Analyses was established by a $500,000 grant from the Ford Foundation in 1956.

Initially, five universities responded to the need: California Institute of Technology, Case Institute of Technology, MIT, Stanford and Tulane. Since then six more universities have joined: Chicago, Columbia, Michigan, Pennsylvania State, Illinois and Princeton.

The objectives of IDA are threefold:

—"To enable and assist the academic community in placing its resources in relevant, effective and contributory apposition to the government.

—"To build the competence of this new science of Operations Research by increasing the numbers of people engaged in it, and by developing the skills thus exercised.

—"To transmit to the nation generally, through channels of teaching and communication, a sharpened appreciation of the real and present problems of preserving the national security."

The largest and still the major contract is to provide the technical support and studies to WSEG. However, since its founding eight years ago, IDA has taken on important work for other branches of the government—although almost all of it is still related to Defense problems.

- **IDA grown up**—The Institute now has four other divisions: Research and Engineering support, International Studies, Jason, and Communications Research. The incumbent president is Richard M. Bissell, a former Deputy Director of the Central Intelligence Agency.

The Research and Engineering Div. is under contract to DDR&E for technical studies of the physical sciences and engineering of such a depth as to be unsuited for the WSEG. By design this group is composed of fairly senior scientists, who function as "intimate" consultants to the Director, DDR&E.

The International Studies Group has done studies for the State Department and the Arms Control Agency. The only study that has been identified by name was one on Southeast Asia for the State Dept.

The Communications Div. does classified research in this area for DOD. It is physically located on the Princeton campus.

Jason represents one of the most interesting activities of IDA. This group was created as a consequence of a belief on the part of older scientists that the younger generation was not being exposed to the key unsolved problems of the nation's defense. Dr. Charles H. Townes, now Provost of MIT and better known as inventor of the maser, was the guiding force behind the establishment of Jason.

Basically, the group—consisting of 25-30 young scientists—meets for about six weeks each summer to be exposed to defense problems. They are accorded the widest need-to-know and are briefed by the three services, DDR&E and the major agencies of the government. After that they are free to form work teams, think about these problems and research them.

IDA has a professional staff of approximately 225, with 150 supporting personnel. Its total income from government work is at the level of about $10 million per year, with a fee that varies between 4-5% and averages slightly above 4%. ■

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Industry Comment Shows Poor Rapport

Need for directorate is recognized but its effectiveness is debated; big firms least disturbed by centralization

TO FIND OUT what industry really thinks of the Office of the Director of Defense Research and Engineering, it is necessary to offer spokesmen the cloak of anonymity or, so they claim, risk wrecking their careers or destroying company profits.

Not everything industry has to say about DDR&E is derogatory. But some observers wonder whether the comments taken altogether do not indicate a lack of trust and understanding, of freedom of expression and criticism, between industry and the Dept. of Defense.

One industry spokesman noted that "you don't hit your customer in the face and then try to sell him something."

Another said, "this is entirely similar to the secret ballot, the cloak of anonymity that you give to the voter on election day, guaranteeing him no reprisals."

There was also the feeling that industry would be caught in the middle, regardless of what comment it made. Praise for DDR&E can get the military mad at you, and seeming to lean too much toward the services can incur the wrath of DDR&E.

• **Necessary, but not sacred**—Industry says it feels that DDR&E, or something like it, is a very necessary creature and that the directorate is sincerely trying to do a good job. But opinions about how it should operate—and how it in fact is operating and with what success—vary considerably, even among persons who have served both in DOD/DDR&E and in industry.

One top industry executive, now a vice president with a major prime contractor after having served in DDR&E, believes the directorate "should not uncouple itself from the difficult task of translating research and development into useful products." He feels it is too much inclined toward establishing policy and then leaving the "doing" up to others.

On the other hand, another former high-ranking Pentagon R&D official now in a high industry position notes with satisfaction that there is a "growing tendency for DDR&E to make decisions and then leave the 'doing' more in the hands of the military services and industry."

Differences in background probably account for such divergent viewpoints. The first executive quoted is a civilian trained as a scientist and engineer; the second had been a career military officer.

A fundamental philosophical difference is involved in these two viewpoints, and much of industry's concern and comment about DDR&E is centered on this fact. Between the two views is the feeling that no hard line can be drawn, that as a general rule DDR&E must strike a happy medium and play each situation by ear.

"Obviously, DDR&E cannot get into the details that the services do", a spokesman said. "On the other hand, it must be able to recognize details which may look trivial, because in the end some trivial detail that cannot be solved is the reason some systems cannot be built."

• **Industry beefs**—But there remains considerable industry feeling that there is—or could be in the future—too much centralization of R&D in DOD, and that there is not enough military and industry input in DDR&E decision-making.

Some of the comment is fairly caustic.

"Most people are of the opinion that the civilians in DDR&E handle their business in a very high-handed fashion," said an executive of a major prime. He complained that most of the DDR&E civilians lack military experience and fail to use the military experience available to them in the Pentagon. He said that while DDR&E tries to apply logic, the results don't reflect either logic or reason.

A spokesman for another well-known company agreed, and added that he felt DDR&E also was responsible for some stifling of research through its emphasis on cost effectiveness. While granting the importance of economy, he said its overzealous application sometimes frustrates research into things that have no immediately clear objective or application. Yet, he pointed out, fundamental research is essential in producing feasiblity guidelines and in eventually providing criteria for cost effectiveness.

The spokesman conceded, however, as did other critics, that "they have managed to shoot down a hell of a lot of stuff that needed killing."

• **Cemetary for ideas?**—Another major contractor declared that although DDR&E was "created with a good purpose in mind, in practice it has turned out to be simply another hurdle to get over when you have a new project—just another place where things get studied to death. In a sense, it's just another way of doing nothing.

"The problem was that you already had to convince so many people you were right. Now add to this the DDR&E, and you have to go through the same thing again. We don't feel it is a question of military versus civilians—it's just that you've got another hurdle."

The spokesman conceded that DDR&E performs a valuable function in blocking undesirable programs, but complained that it also prevents useful programs from getting started.

A marketing manager for another large firm asserted that DDR&E needs more military men with actual operational experience.

"I would throw out all those planners who have spent the last 20 years at Wright-Patterson, Langley and elsewhere, either in procurement or in R&D, and bring in people with operational experience. People who have spent their entire military careers buying equipment or R&D know what to do when it comes to procurement of hardware that is already established. But when it comes to using imagination and vision, these people aren't worth anything."

• **Overcentralization charged**—On the subject of centralization, an industry spokesman drew this analogy:

"In industry we are confronted with somewhat the same alternatives, whether to have centralized R&D and then have new products feed out to our producing and marketing organizations. Most industrial organizations will allow R&D to take place in each one of the operating elements; very seldom do they try to centralize all R&D and then just have satellite production units, particularly if they are in a broad product area."

He pointed out that industry often delegates R&D to operating divisions to take advantage of more ingenuity, more people and more opportunity for exploiting developments. "What if a centralized research agency in DOD did not come up with an undersea warfare device? The Navy would be out of business. It is better to have R&D centered at the using agencies."

Others do not agree with this analogy. "The situation with DOD is similar, but so vastly more complicated by its size that you cannot make a real comparison here," a spokesman said. And, he added, "the fact is that the procedure in industry varies considerably among companies."

Also, another pointed out, the technical risk to a contractor is not as great as to DOD. "Industry can be victimized by its own enthusiasm on occasion. DOD cannot afford that."

Not everyone queried in industry agreed that control is too centralized, that it is even being attempted, or that DDR&E should remove itself from the picture once policy and broad guidelines are established.

Spokesmen accuse each other of lack of understanding of the DOD picture. Judging from some of the comments made, this would seem to be true.

Interestingly enough, executives of some of the larger, more successful companies seemed less disturbed than their smaller business brethren.

"There is no question but that DDR&E is playing a stronger role as time passes in directing R&D efforts," said one director of marketing. "I suspect the ultimate objective is to create an organization that will run the whole thing.

"I suspect DDR&E influence is much stronger than just the coordination function and it is taking over some of the prerogatives of the services. But from the industry point of view, this is good. Certainly the system under which we worked previously was easier. But under the previous system the services collectively were buying themselves into pretty serious fiscal problems.

"But the paradox here is that the defense budget hasn't come down as a result of this great coordination effort now under way, and it doesn't seem as if there are a great many more weapon systems coming out the other end."

The marketing director of another large and well-diversified company thought that DDR&E early in its history went "a little overboard in controlling the process of development evolution, but now this is swinging back to a more normal relationship in which the operational representation is better heard."

The director of research engineering for one of the most successful aerospace firms in both civilian and military markets declared that DDR&E has such a small staff it would be impossible for it to try to monitor all programs, ". . . let alone try to run things for the services and industry. They can only hit certain high points, maybe not even all the big programs once a year, so they are clearly leaving most of the job to the services."

• **Relaxed view**—To some extent, opinions expressed appear to correlate directly with the executive's job. At least some executives who regard themselves primarily as salesmen don't find it difficult to operate on the theory that the customer is always right—and that they are going to make a sale come what may.

Officials of the larger companies appear to take a broader, cooler view and complain less about the problem of understanding the customer.

A marketing director in a corporation that in one recent year ranked first in defense sales declared there was no problem in maintaining good relationships with the customer and understanding his wants. "They tell you how to run your business and if you take the trouble to understand that, then I don't see how you can have anything but a good relationship. When the DOD budget was presented to Congress, Secretary McNamara and Dr. Harold Brown made the most complete statement of management policy that I have seen anywhere—and they operate in accordance with it."

To others it is not quite so clear. "There is feeling in some places that DDR&E is trying to run the services' business for them," a marketing director said.

Still another marketing director, in a West Coast aerospace giant, said he could list half a dozen things wrong with DDR&E operation "but I can't think of anything so horrible that I would make it a special item. I can't offhand think of any improvements that would make it work a lot better than it is."

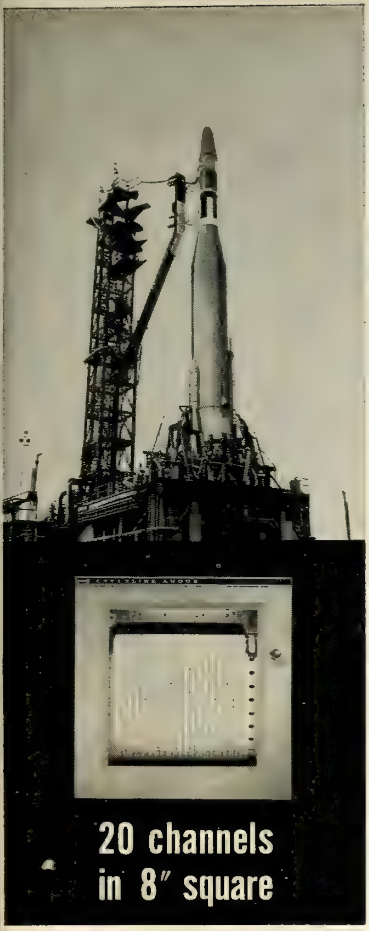
A research and engineering executive of another corporation that has ranked first in sales praised DDR&E as a technical group "that is trying to do a job that is extremely difficult. It is trying to approach the problem on a rational basis, to do the best job that it can with a tremendous technical management situation."

• **"Rules are different"**—An official holding a similar position in another big firm criticized those who blame DDR&E for program cuts. "The only real question in many minds about these decisions is why it took DOD so long to act. I don't think people who understand the problem can find any surprise in these decisions.

"When the military services ask for more money than the White House is about to grant, somebody must decide where to cut. I'm not sure but what the services wouldn't make the same cuts if they were handed the job themselves. Somebody has to make peace between competing agencies, and whoever gets that job is going to be the whipping boy on occasion."

A vice president-development planning said DDR&E was brought into existence "simply because it's a matter of working under different ground rules in peacetime than you do in war. In war, there is no time to worry about cost. But in peacetime, rules are different. President Eisenhower laid down a fundamental change in national defense policy in saying he wanted a strong military in-being force at all times, and at the same time wanted an expanding peacetime economy. This policy has not been changed.

"Before that, in a relative time of peace, we could just cut back our defense establishment to the bone, but Eisenhower recognized that we could not afford to do so. Since that time the cost of both development and procurement of weapon systems and their maintenance has become one of the key factors in deciding what weapons to go after. We had never faced this before. Now the Secretary of Defense has to have an organization to help him make these major decisions." ■



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Services' Relationship with Directorate Is Improving Steadily

Military praises growing competence, but still sees weaknesses in operational aspects; misunderstanding at field level is problem

HARMONY, at least on the surface, marks the relations of the military services with DDR&E. In fact, all three services were anxious to assure MISSILES AND ROCKETS that understanding and cooperation are increasing. This is undisputably the case.

High-level officials in DDR&E, however, evaluate the situation somewhat differently. They candidly admit that the battle is not won. They say that the Air Force, which has borne the brunt of the clashes with DDR&E, has realized the change in environment and is "coming around." The Navy is just beginning to feel the full impact of DDR&E requirements and one Defense official expresses himself as "sanguine" about the result. Finally, the Army has been enjoying a "honeymoon" during the buildup of its capabilities for limited war; as soon as the Procurement for Equipment and Missiles account begins to drop, however, the Army can expect to go through an adjustment phase.

The military feel that the competence of DDR&E has improved immeasurably in the past several years. "They have gotten rid of a lot of people and brought in management people with engineering experience," in the opinion of one officer, who adds that this has increased DDR&E's competence "dramatically." The main problem, in the military view, is that although DDR&E understands the technical problems well, it is still weak in dealing with operational considerations.

"They haven't looked at the operational aspects as much as they have the technical and cost considerations," in the opinion of one officer; as a consequence, he complained, they do not attach enough weight to the flexibility of a weapons system. Given flexibility, he said, a system designed to accomplish one mission may be called on to perform many on the battlefield. Use of the B-29 as a close-support aircraft in Korea was a graphic illustration of this.

Cost/Effectiveness also ignores operational restraints imposed on the employment of a weapon. In the Korean action, for instance, weapons were used in a way that was very carefully restrained and considerably less than optimum.

To cope with this problem, one of the services has adopted the policy of assigning only its best officers—technically trained but with a wide background of operational experience—to DDR&E. This serves two purposes: first, to educate DDR&E about the operational aspects of a proposed weapon; second, to provide a sympathetic response to that services' proposals from someone who understands both the need and the problem.

All three of the services consider their working relationships with DDR&E to be excellent, but they admit that this realization has not trickled down to field installations. In fact, it would appear that DDR&E is being blamed for many actions actually taken by military staffs.

One military chief of R&D points out that his staff sends back more proposals to field centers than does DDR&E. He is trying to educate field installations to the new environment through a semi-annual orientation of officers in his service.

● **New set of tactics**—The services are still willing to fight a major battle for "essential military requirements." But they have made two major changes in tactics. First, much more thorough preparation for battle is made; judgments which in the past were considered intuitive are now quantified; studies, analyses and tradeoff studies are prepared; and an evaluation is made that the operational system can no longer do the job and the proposed replacement represents a quantum improvement in capability.

Second, use of what might be called "guerrilla warfare" in the press has been eschewed to a large degree and replaced by more eloquent appeals to the Pentagon hierarchy and Congress.

By and large, however, the services realize that new systems are extremely expensive and that DDR&E is under considerable pressure to keep R&D expenditures down.

To illustrate the high cost of modern weapons systems, the B-52 force represents a $20-billion investment—not a small factor in any consideration to scrap this force in favor of a new bomber—and the ballistic missile investment over the FY '62-65 period has been $30 billion.

A partial list of systems under development which, if approved for deployment, might involve R&D and investment costs of over $1 billion includes:

Communication Satellite System
Advanced Manned Bomber
Improved Manned Interceptor
Sea Surveillance System
Advanced Sea-based Deterrent System
Low-Altitude Supersonic Vehicle
Manned Orbiting Laboratory
Titan III

Satellite Inspection and Intercept System
Advanced ICBM system
Mobile Medium Range Ballistic Missile
Nike-X System
Nuclear-Powered Surface Ships (destroyer class)
TFX
Long-Range Cargo Aircraft (10,000-mi. range)
Close-Support Fighter Aircraft System
New Aircraft Tactical Missile System
Early Warning Satellite System
Implementation of Army Air Assault Division Concept.

The very length of this list precludes development of all of these systems. Very careful choices—promising the maximum return on investment—must be made. Added to this are pressures resulting from other Governmental requirements and the increasing belief that the Soviets must be countered on the lower spectrum of warfare. This is the environment within which not only the services but also DDR&E must function.

● **Making choices**—The realization that choices can indeed be made among all the "good" technical ideas is just now dawning within the military services. As one senior officer put it, "We are now a decade into the 'technological knee' and maybe that is long enough to be able to take a look at our accomplishments. We are beginning to realize that choices can be made, that we can say 'yea' or 'nay' just as our grandfathers could."

He concedes that the techniques for making these choices are only now evolving, and he credits DDR&E with taking the leadership in learning how to make these choices and with assisting the services in this process.

Another service representative attributes the power of DDR&E to an abrogation by the services of their responsibility to make the difficult choices. The services are not accustomed to taking a long look at their weapons systems in relation to other weapons systems, he declares, so that when the time comes to choose between competing developments the decision is passed upstairs. DDR&E, he emphasizes, is not reluctant to choose. Under these circumstances he sees little justification for the military to complain.

Now the services are learning that the place to make these decisions is within the service—before they get to DDR&E. Also, a new phenomenon is evolving within the Pentagon: cooperation rather than competition for the R&D dollar. The three services are now making initial attempts to mesh their R&D efforts, wherever possible, in order collectively to get as much as possible out of the RDT&E budget. Interest on the part of two or more services in the same program gives it just that much better chance of surviving the civilian axe. "We are making some headway," one R&D chief notes.

● **Selling weapon variety**—One of the clearest examples of the differing approaches of DDR&E and the military services involves the determination of how many weapons are required to perform a given mission. This is most apparent in the case of setting the proper mix of strategic forces.

DDR&E's approach to this problem is that once the proper level of strategic-forces mix is reached, increases in that level do not add anything to the military posture and, beyond a certain point, will evoke no corresponding response from the Soviets. Consequently, they argue, such adjustments are not worth the cost.

The military attitude toward the same problem is that the greater the number and variety of weapons against which an enemy has to defend, the less likely he is to be able to counter all of them effectively. They also contend that if the enemy should neutralize a primary weapon, a secondary weapon may then become the margin of superiority.

Thus, the choice of approaches is between Scylla and Charybdis, and is unlikely ever to be completely resolved.

Another example of differing philosophy involves basing concepts. A primary military concern is the vulnerability of weapons systems. In order to reduce this vulnerability, alternate basing—such as mobile launchers (railroad, ship or vehicular), hardened and dispersed sites and "dormant" weapons—is highly attractive.

However, the high cost of this, and its relatively minor addition to overall force effectiveness, tends to cause DDR&E to disparage the alternate-basing concept. In fact, the directorate does not consider it a valid reason for a weapon system development.

● **Services, Industry, DDR&E**—Part of the misunderstanding about the DDR&E-military relationship is a direct result of the misunderstanding in industry of the role of the civilian group. At least two of the services feel that industry's misconceptions have fostered the idea of conflict between the two levels of DOD.

Industry, they say, does not know where to sell—whether it should concentrate on DDR&E or the military services, and this confusion has created a great deal of waste motion. Further, difficulty is fostered, they contend, by "industry concern over empty plants."

DDR&E, all three services point out, is not in the operator role. After approval of the services' funding and plans, each service determines who gets a particular contract and how the money is spent. Therefore, the place to really sell to DOD is still in the bureaus, divisions and commands of the individual services.

For the company that wants to present its ideas to the Pentagon, military officers recommend use of the "shotgun approach"—presenting the proposal to both DDR&E and the service involved. In many cases, they point out, a company will find that, if it goes to the service, the interested party in DDR&E may sit in on the presentation. Conversely, if they approach one of the Deputy Directors, they are likely to find interested people from the service attending their briefing. There is very close communication on matters like this between DDR&E and the services.

At DDR&E level, officials stress that they don't think that they "can tell the services to do something and get the proper response." Furthermore, unless the idea is extremely important—and there are not more than two or three of these out of 300 a year—the Defense officials won't even try. In the case of these two or three ideas, however, DDR&E has no compunction about telling the services to act.

There is a feeling within the services that, as the Defense budget starts to contract, industry will have to rely more and more on DDR&E for long-range guidance in weapons development.

● **Future problems**—As the systems under development prior to the advent of the present DDR&E staff come to fruition or are cancelled, there are likely to be fewer and fewer "grand debates" such as those over the RS-70 and *Skybolt*. These arguments are apt to shift to the directions which research and exploratory development are taking—a much harder subject to debate than a piece of hardware.

A future area of controversy probably will be DDR&E's examination of the methods by which the military services specify requirements. There is a belief in the civilian staff that the military specify too great a range of conditions which a system has to meet—from Arctic snow to jungle fungi. Perhaps a degree of area specialization in weapons is possible; it is being explored.

These conflicts are likely to be intramural, however. The overall feeling is that DDR&E is objective, honest and reasonable. The schism that existed between DDR&E and the services under Dr. York has been healed, and an effective and informal rapport has been established. This feeling was summed up by a military officer in this way: "We don't always agree, but we can definitely sit down with these people and thresh the problem out. And both sides benefit." ■

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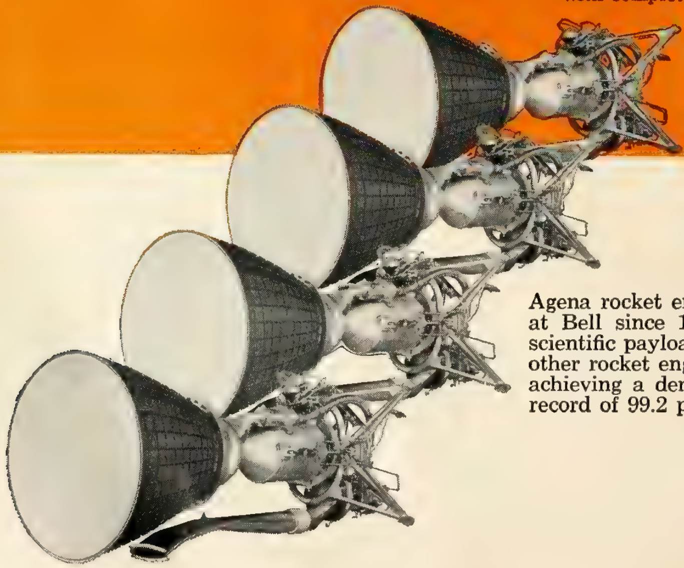

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Bell Salutes
USAF Ballistic Missile
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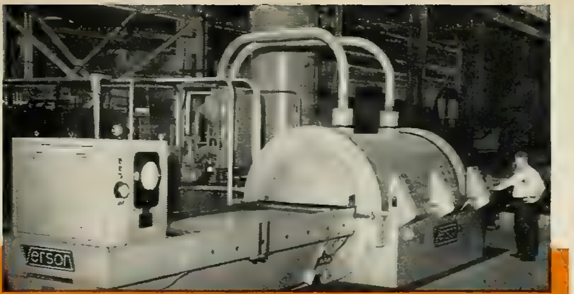
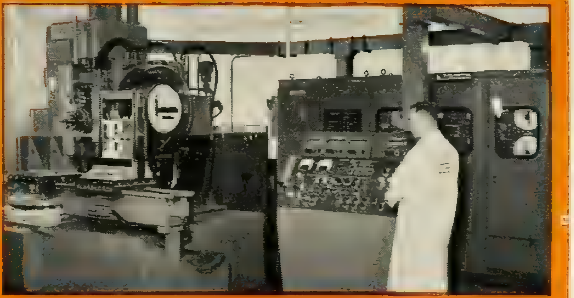
One of several electronics and electro-mechanical equipment test and assembly areas at Wheatfield where Bell recently constructed a new clean room that more than doubles its Class 4 facilities. In addition, an avionics production facility in Cleveland, Ohio and an electronics laboratory in Tucson, Arizona round out Bell's avionics production capability.



New hydraulic presses, such as this one with heated platen, for forming metals such as titanium and magnesium, keep Bell production methods up to date . . . production costs down. Virtually all types of conventional and exotic metals can be fabricated including high-temperature steels, zirconium, Inconel, Monel, Stellites, and molybdenum.

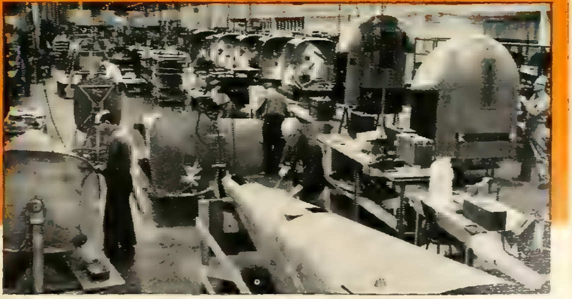
One of many data acquisition points which are tied into the large general purpose IBM 7090 computer in Bell's 32,000 sq. ft. Electronic Data Center. This digital and analog computer network is an important PERT and Value Analysis tool and is used in support of all phases of management, research, planning and production.



Numerical or tape-controlled automatic machinery like this newly-installed Milwaukee-Matic "Machine Center" speeds production by combining milling, boring, counterboring, countersinking, drilling, reaming, and tapping operations in one machine. Use of multi-purpose machines reduces the number needed resulting in production efficiency.

Top level and supervisory manufacturing staffs at Bell average 20 years experience with know-how of the very latest management-production methods. A typical program-management team (left to right) includes the Directors of Manufacturing . . . Quality . . . Reliability and Value Engineering . . . Chief Aerospace Engineer . . . Supervisor, PERT (standing) and Assistant Manufacturing Director.

Helicopter cabins and tail booms in an assembly area . . . a sub-contract that illustrates Bell's sheetmetal fabrication capability. In other areas, cargo compartment doors, engine cowlings and cargo floors for military aircraft are also in production. Recently negotiated three-year contracts with all major unions provide a high degree of labor cost predictability.



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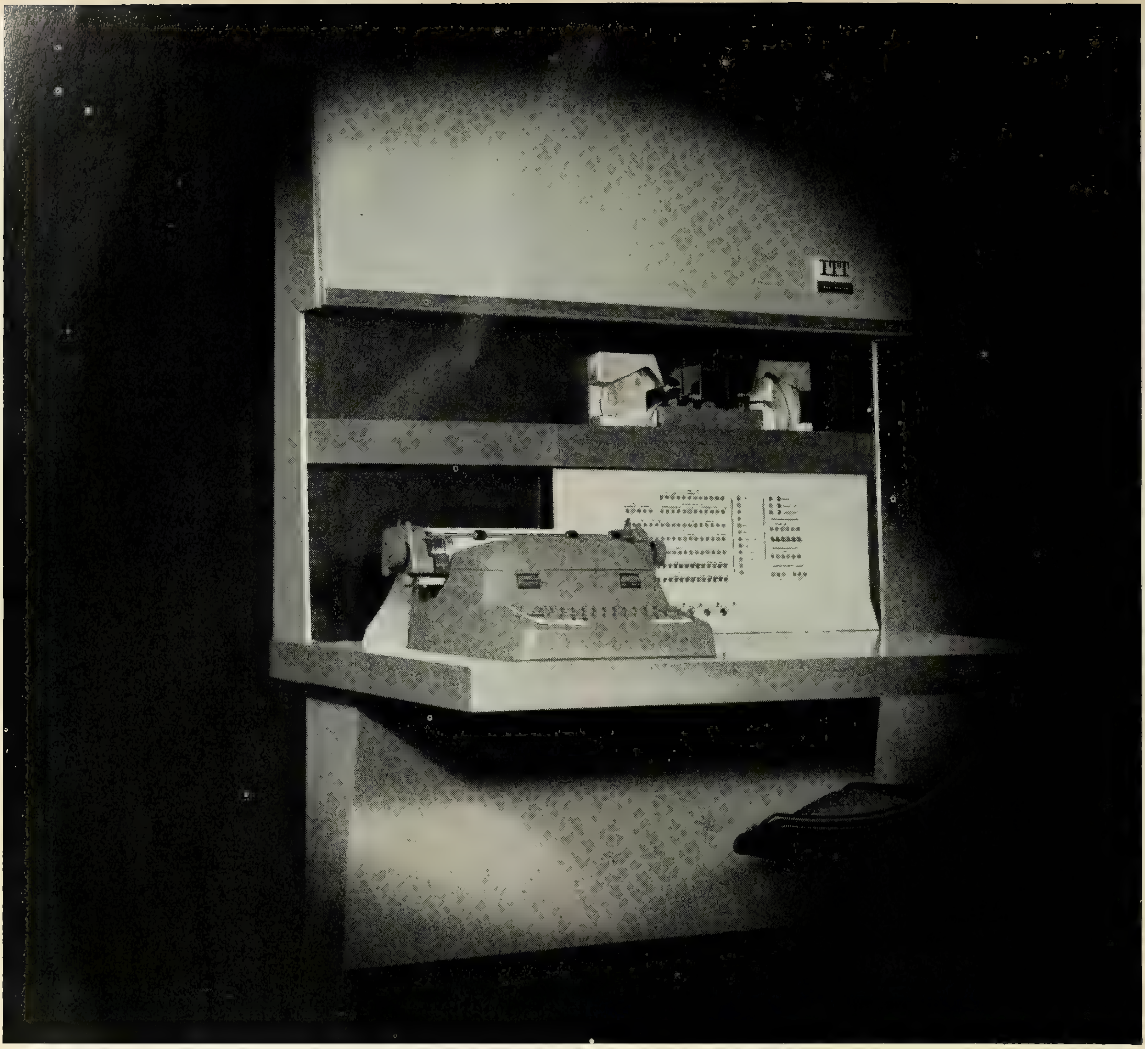

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Polaris sub Sam Houston returns to Holy Loch from patrol.

DDR&E part II

PROGRAMS

New Tactical Missile Contracts Expected To Yield Billions for Industry

Attainment of planned strategic force levels triggering trend toward improving U.S. capability to conduct conventional war

A HOST OF NEW tactical missile systems now nearing development is expected to mushroom into new industrial contracts worth billions of dollars.

Most imminent is a new advanced naval surface-to-air missile which will reach the program-definition phase late this year. Total cost of its R&D alone is estimated at about $400 million.

Other new systems, under study by DDR&E and the related military services, which may move into development in a period ranging from a few months to years include:

—Two interim air-defense systems for the field Army. One is needed in the immediate future to replace antiaircraft weapons. The other will be designed for deloyment in the late 1960's or early 1970's. It will be a less expensive and complex version of the *AADS-70* missile system.

—The *Advanced Asroc* antisubmarine missile, with extended range capability and new guidance systems.

—A *Subroc*-like missile capable of carrying a conventional warhead.

—A homing antitank missile, which DDR&E believes will require a real technological breakthrough.

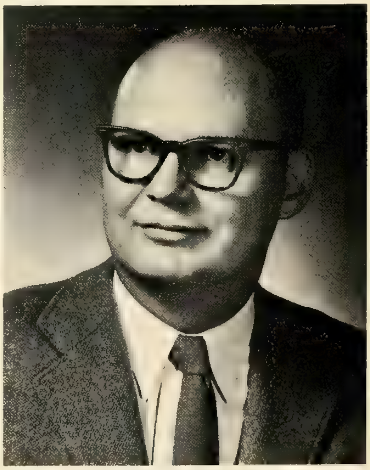
—A new air-to-surface missile which can be fired against submerged submarines. Conversely, the Navy is also studying a requirement for a missile to protect submarines from attacking helicopters.

—A surface-to-surface missile, proposed by the Navy Department, which could be fired from ships as well as by marines in the field.

—A new air-to-air missile system for use by the Air Force on the TFX airplane.

—Missiles for Army helicopters—new requirements are probable over the next two years.

The list of proposed tactical missile systems makes it clear that activity in this area offers the missile/space industry its biggest potential market for new business over the next few years.



JOHN L. McLUCAS, Deputy Director, Tactical Warfare Programs.

The upsurge in the program is not a sudden development. In the 1960-61 period, as the U.S. strategic missile force buildup began leveling off, DDR&E officials realized that this country must develop its conventional war capability.

In 1962 and 1963, a list of neglected areas in tactical attack and defense was drawn up. It is still being used by the Pentagon in its development of new missile systems.

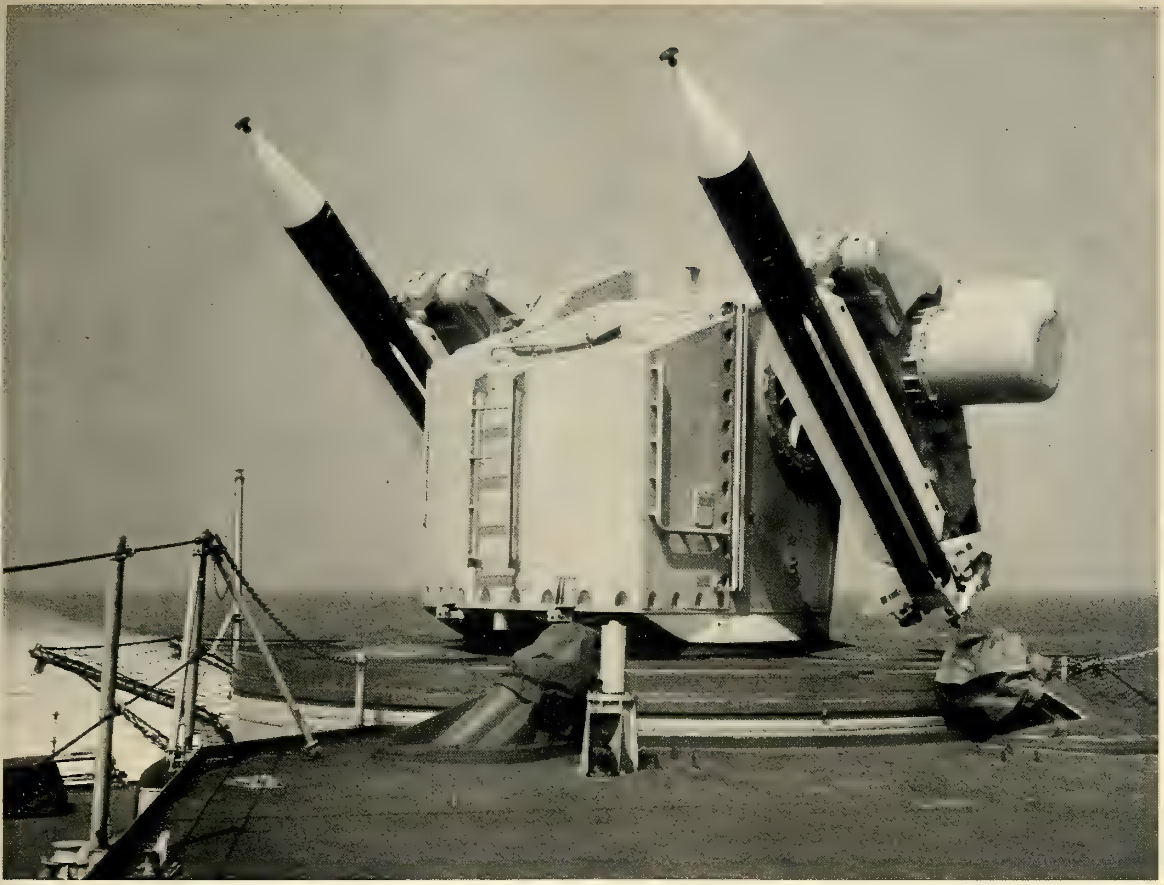
Following are some of the more important results of the review of U.S. tactical warfare capability.

- **Naval surface-to-air missiles**—There are two new developments in the Navy Dept.'s effort to defend the fleet from air attack.

In the next couple of months, a decision will be made between the existing *Terrier* and *Tartar* missiles for a new standardized system which will begin to go into the fleet in Fiscal Year 1966.

Of far greater importance, however, is the development of an advanced surface-to-air missile, which will reach the program-definition phase late this fall. It's expected that there will be a go-ahead within 18 months for full development of a system that will be applicable to all parts of the active fleet.

Eleven firms have been invited to submit bids by April 15 for study con-



NAVY'S TARTAR surface-to-air missile. Service will soon decide between it and Terrier as standardized FY '66 fleet weapon.

tracts which will be awarded around July 15. Four firms will be selected to make the studies, which will last three months. It is expected that the number will be trimmed down to two or three firms who will carry out the program-definition, scheduled to begin around Nov. 15.

Changes in the Navy's surface-to-air missile systems stem from problems which developed as the *Terrier, Tartar* and *Talos* missiles began to be fitted on ships in sizeable numbers during the last couple of years.

The difficulty centered mainly in the integration of bits and pieces of components procured from many different sources. A three-step program was initiated to bring the air-defense fleet into reasonable working condition.

First step calls for getting rid of defective parts and starting a re-engineering program to improve the system. Standardization of the radar system for each missile also was included.

Second step will be selection of either *Terrier* or *Tartar* as a standardized missile to go into the fleet beginning in 1965-66.

Third step is to develop a new advanced surface-to-air missile to replace the three "T" 's, starting in 1971.

The cancelled *Typhon* missile originally was designed to fill the requirement, but the Navy found that the system was too big to fit some of its ships.

DDR&E believes that no technical breakthrough is required, because *Typhon* produced all the basic building blocks needed. The new missile must merely be smaller, more reliable and cheaper.

The 11 firms invited to submit proposals for the study of the *Advanced Surface Missile System (ASMS)*—including the radar, launcher and the missile—are Boeing Co., General Electric Co., Hughes Aircraft Co., IT&T, Philco, Raytheon, Sperry Rand, Sylvania, RCA, Westinghouse and North American Aviation, Inc.

Total R&D cost has been estimated at $400 million.

- **ASW & subs**—In this area, the most imminent new development program is the *Advanced Asroc* antisubmarine missile. DDR&E approval is expected in the next few months and FY '65 funds may be used to initiate its development.

Primary objecive of the new missile would be to increase its range over the *Asroc* missile currently operational on Navy ships. The longer range is required by the new longer-range sonars under development. The advanced missile would be an almost entirely new bird, with new motors and a new guidance system.

One alternative to the *Advanced Asroc* is the use of helicopters to defend ships against enemy submarines. DDR&E officials believe, however, that helicopters will not be able to match the performance of the new missile and also will not have the needed all-weather capability.

Two other new Navy ASW and one submarine-based missile system are being studied.

The first is a *Subroc*-like vehicle that would carry a conventional warhead. The key problem for the missile is the fire-control system needed to place it within lethal area of the target.

If the program is approved, officials report, the current *Subroc* missile would have to be extensively redesigned.

It is emphasized that the program still is in the study phase at the Navy Dept. and has not yet been proposed to DDR&E.

Another program under serious study is an air-to-surface missile which would be fired from Navy patrol planes against enemy submarines.

A decision on development of this system will be made in about one year.

The Navy currently is studying existing weapons, including the Martin Marietta *Bullpup,* to determine if they can fulfill the requirement. Officials report that preliminary studies have not been encouraging.

Although some officials predict that a new missile will have to be developed, the Navy also is considering an unnamed foreign missile to which a U.S. firm has license rights.

The air-to-submarine missile presents an unique problem in its sensor, which must be used against a submerging or partially submerged submarine. It also presents nose design problems because it has to penetrate the water interface.

The third new system under study by the Navy would give submarines the power to counterattack against attacking helicopters. The project is still very indefinite and the Navy is now attempting to determine its priority.

One concept under consideration would modify the *Sidewinder* missile so that it could be launched from beneath the ocean's surface.

- **Navy surface-to-surface missile**—The Navy and the Marine Corps have been pushing for this new missile for several years. It would be used against ships and shore targets.

Thus far each Navy proposal has been rejected by DDR&E and sent back for further analysis. The system, however, is currently a line item in the FY'66 budget being prepared by DOD.

The *Lance*—the Army's multipurpose, surface-to-surface, 3-30-mi.-range missile—has been suggested, but it probably wouldn't fill the bill in its present configuration. Launching from shipboard provides additional stabilization problems which the *Lance* system may not be able to handle. Another constraint against using *Lance* is that the Navy wants the surface-to-surface missile to be compatible with existing shipboard launch systems.

Informed sources report that for the past two years the Navy has fought for development of an entirely new missile called *Taurus* to do the job.

- **Troop defense**—Air defense of the field army is one of the major deficiencies facing U.S. tactical warfare planners. Such systems also illustrate what some DDR&E officials consider the biggest management and technical weakness of DOD and industrial officials.

As a result, two interim defense systems are now under intensive study.

A decision on one of the systems will be made in a few months. The other has a longer leadtime and will not have to be operational until the 1970's.

- **Short-range**—The short-range air defense problem results from the early deactivation of conventional antiaircraft guns and what is called a mismatch between the statement of requirements for a system, its cost and the state of the art.

Tactical warfare planners now feel that they may have gotten rid of conventional antiaircraft guns too soon.

Two defensive systems currently under development—*Redeye* and *Mauler*—will not be ready as soon as expected. The operational target date is now 1966 for *Redeye* and 1968 or later for *Mauler.*

A new system is needed right now. A decision on which way to go—a new missile or new antiaircraft guns—will be made in the next few months.

It appears that a missile system will be selected, although advanced West German and British antiaircraft weapons are being studied.

One likely possibility to fill the requirement is the adaptation of the *Sidewinder* air-to-air missile. The modification would be relatively simple, perhaps involving only emplacing the *Sidewinder* system on a mobile mount.

Mauler is cited as an example of how the statement of requirements for a missile system can exceed the state of the art, thus causing schedule and development delays.

DDR&E officials believe that too much was asked for when the *Mauler* specifications were written in 1961; as a result, it has run into technical problems and its deployment has been delayed.

"We felt that *Mauler* had to meet all contingencies. This required a fancy and high-powered radar," one official said.

He added that while there will be a *Mauler* later in this decade, it won't have the capability originally planned for it.

- **Long-range**—Air defense of the field army also has a long-range problem.

DDR&E officials are expected to drop major development of the *AADS-70* field army ballistic missile defense system as it was initially planned.

They believe that it will be impossible to build the system in large quantities at a low cost. Total pricetag for the system is $2 to $3 billion, and the current feeling is that U.S. defense can't afford it.

The Army is doing technical tradeoff studies to devise a substitute, which, while not as complex, will still meet military requirements. The report is due about April 1.

AADS-70 was designed to replace the *Hercules* and *Hawk* missiles, as well as to supplement *Mauler* in a complete air-defense system. The current *Hawk* and *Hercules* modification program is a dead-end, and a new system will be needed for use in the 1970's.

- **Antitank missile**—The one area where both Army and DDR&E officials are seeking a breakthrough is in a new homing antitank missile.

Officials are not satisfied with the current crop of such weapons. The *Entac* missile is a purely optical one—in which the gunner sights down on the target similar to using a rifle. As a result, he is exposed to counterfire.

The next generation—*Shillelagh* and *TOW* missiles—use an infared guidance system.

The infrared system also has the drawback of being susceptible to counter-measures. Its guidance accuracy can be thwarted by direct sunlight, rain and clouds.

While officials admit that a ground-fired homing missile has peculiar problems, they hope to develop a missile which will home on the center of the target. This would be most effective against tanks and dispersal targets.

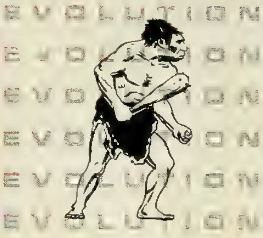
Among the systems being considered to solve the problem are acoustical homing and other radiation systems, including ultraviolet.

Potentially, it is believed, radar may be the real answer. Several techniques have been demonstrated. Thus far, radar can track a tank while it is moving, but as one DDR&E official put it "when it stops, we're licked."

One solution pondered by DOD officials is modification of the Army's *Lance* for use as a radar-homing antitank weapon.

- **Army aviation missile requirements**—DDR&E officials report that there probably will be new requirements for missiles to arm Army helicopters. One concept under study would be application of the *Shrike* antitank missile for such use. Officials refused to reveal details of R&D in this area, but did say it "is something that will develop in the next couple of years."

- **MMRBM**—DDR&E is still committed to the *Mobile Medium Range Ballistic Missile* system despite Congress's recent $70-million reduction in the FY'65 *MMRBM* authorization of $110 million. DOD hopes to continue the missile by reprogramming funds from other projects, but Congress will have to approve the action. ■



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Defensive Systems Office Advances Studies of Exotic Weapons Concepts

Mission requires close coordination with Project Defender personnel, Civil Defense Office; weapons spectrum includes Nike-X, ground-based non-nuclear antisatellite device

THE OFFICE of Defensive Systems under the Director of Defense for Research and Engineering is concerned with some of the most exotic weapons concepts in the Dept. of Defense. These concepts are also among the most highly classified, ranging from a ground-based non-nuclear anti-satellite weapon to use of high-power laser light as a defensive system.

Analysis of the objectives of the Office of Defensive Systems necessarily dictates a look at the activities of two other DOD agencies—DDR&E's own Advanced Research Projects Agency (ARPA) and the Office of the Assistant Secretary of Defense for Civil Defense. The latter is not part of the DDR&E organization.

The functions of these three offices meet in the effort to establish an effective defense against enemy intercontinental ballistic missiles and submarine-launched missiles.

The most viable A-ICBM being watched by the office of Daniel J. Fink, DDR&E's assistant director for defensive systems, is the Army's *Nike-X* system.

Fink's office is organized in relation to the threats posed to the U.S. by a potential enemy, ranging from those carried by air-breathing vehicles (manned bombers) to space-borne threats. The Defensive Systems Office is staffed by one representative each from the Army and Air Force, plus two civilians, in addition to Fink. It is part of DDR&E's Office of the Deputy Director for Strategic and Defensive Systems. Fred A. Payne, Jr., is deputy director.

Nike-X is the terminal interceptor now under development as the most feasible advanced system for destroying incoming warheads after they have reentered the atmosphere. A decision to deploy the system could come no sooner than this fall, according to DDR&E spokesmen. By that time, extensive data will have been gathered from *Zeus* tests being conducted at Kwajalein Atoll in the South Pacific.

Even if the decision to proceed with development and ultimate deployment is made, DDR&E officials say an operational system will be at least 10 years away. Such a system might consist of up to 30 batteries of mixed defensive weapons, with the single-stage, extremely-high-acceleration *Sprint* literally the "ace in the hole."

In testimony before the House Armed Services Committee, Defense Secretary Robert S. McNamara estimated that the operational system might carry a pricetag as high as $16 billion. The first battery, say DDR&E officials, could be in place four years after the deployment decision is made.

- **Close tie with ARPA**—The mission of Fink's office requires close liaison with ARPA, and particularly with Dr. Samuel J. Rabinowitz, that agency's director for ballistic missile defense in Project Defender. The importance attached to Defender can be deduced from the fact that it represents $128 million of ARPA's FY '65 budget request of some $280 million.

Studies conducted in Project Defender yielded the data on which the decision was made to proceed with development of a terminal A-ICBM system as the most feasible kind of defense.

These same studies ruled out as impractical any launch phase or mid-course interceptor. An example of a launch-phase A-ICBM system is the BAMBI (Ballistic Missile Boost Intercept) satellite-based system. ARPA officials concluded that boost-phase interception was impractical and too costly to implement, chiefly because of this nation's lack of accessibility to Soviet launch sites.

Project Defender personnel, however, will continue to look at boost-phase interceptor possibilities. They haven't ruled them out as physically impossible, but they don't see much likelihood that the lack of accessibility to launch sites can be overcome. As one DDR&E officials put it, the Russians "just won't let you in over there."

Studies in Project Defender will also continue to pursue programs that might make mid-course ICBM interception feasible. The mid-course phase encompasses the time between propulsion burnout and the vehicle's re-entry. Chief problem here is discrimination, ARPA spokesmen say. Heat seeking is ineffective, and since there is no interaction of the vehicle with the atmosphere, the defense has no idea of the size and weight of the incoming object.

- **Defender detailed**—Defender is divided into three principal areas of activity, report ARPA officials: 1) a measurements program; 2) a technology program, and 3) systems studies.

The measurements program concentrates on the phenomena associated with ICBM re-entry, yielding information that is useful to both Fink's Office of Defensive Systems and to Payne's personnel concerned with strategic systems. These data, combined with those compiled by Defensive Systems' own measurements program, give Fink's personnel the tools to discriminate between decoys and the re-entry vehicle.

The information also helps Payne's strategic mission by contributing to the development of better penetration aids for U.S. ICBM's.

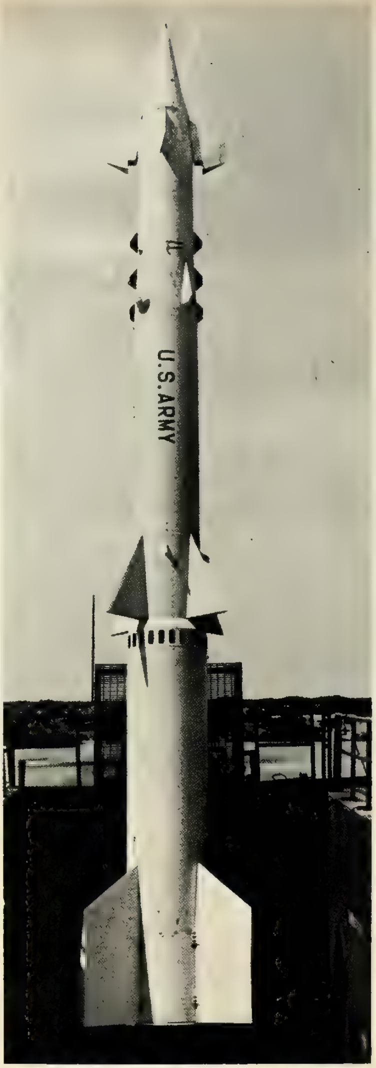
Defender's technology program has spawned some valuable ideas in the areas of defensive radars and active defense. For example, the ESAR (Electronically Steerable Array Radar) begun early in Defender was the first fully instrumented phased array, according to ARPA officials.

Now *Nike-X* is depending on phased arrays—chiefly the MAR (Multi-function Array Radar) being developed for the Army by Sylvania Electric Products, Inc. MAR is scheduled for testing soon at White Sands Missile Range, N.M.

In active defense, Defender's technology program is looking beyond *Sprint* to even more advanced interceptors or "Super *Sprints*." One of the most important developments in this area was ARPA's recent two-year, $6-million HIBEX award to the Boeing Co. HIBEX (High-G Boost Experiment) will study extremely-high-acceleration missiles for A-ICBM use. Though it is not yet systems-oriented, HIBEX will involve Boeing's building and firing an undisclosed number of missiles, also at White Sands.

Hercules Powder Co., as subcontractor to Boeing, will develop the solid motor for HIBEX. Initially, HIBEX will determine whether the desired acceleration can be obtained, and if so, whether the missiles can be controlled at the speeds anticipated.

- **ARPA optical studies**—Another area of exploration in ARPA's technology program covers optical devices in the infrared-through-ultraviolet spectrum. This could conceivably include a high-power laser research program that ARPA officials told MISSILES AND ROCKETS they were pursuing to determine the feasibility of laser use in missile defense. They would give no further details on the program.



NIKE-ZEUS, shown here, may give way to Nike-X, now under development.

Another DDR&E official, however, says that lasers are not yet known to be useful in missile defense, principally because they are hampered by inclement weather or cloud formations. This would indicate that whatever laser systems ARPA is considering in a defensive role would be spaceborne.

The systems study portion of Project Defender is aimed at developing "optimum systems to do specific tasks," says one ARPA spokesman. One of the most provocative—but classified—studies under way in this area is a ground-based, non-nuclear satellite-kill device. ARPA officials told M/R only that such a system is feasible.

Project Defender's systems studies program must also be concerned with missile defense concepts that seem exotic, given the present state of the art. In this area, ARPA planners are looking at systems that are fundamentally different from the radar/interceptor concept. They must first determine whether such systems are feasible, and if so, plan the course of further investigation.

- **Surveillance in defense**—Returning to consideration of the spectrum of responsibility with which Fink's Office of Defensive Systems is concerned, it is useful to focus on the office's surveillance mission.

Existing surveillance, control and warning systems include SPADATS (Space Detection and Tracking System) and BMEWS (Ballistic Missile Early Warning System)—both concerned with ICBM detection—and the SAGE (Semi-automatic Ground Environment) and BUIC (Back-Up Interceptor Control) systems.

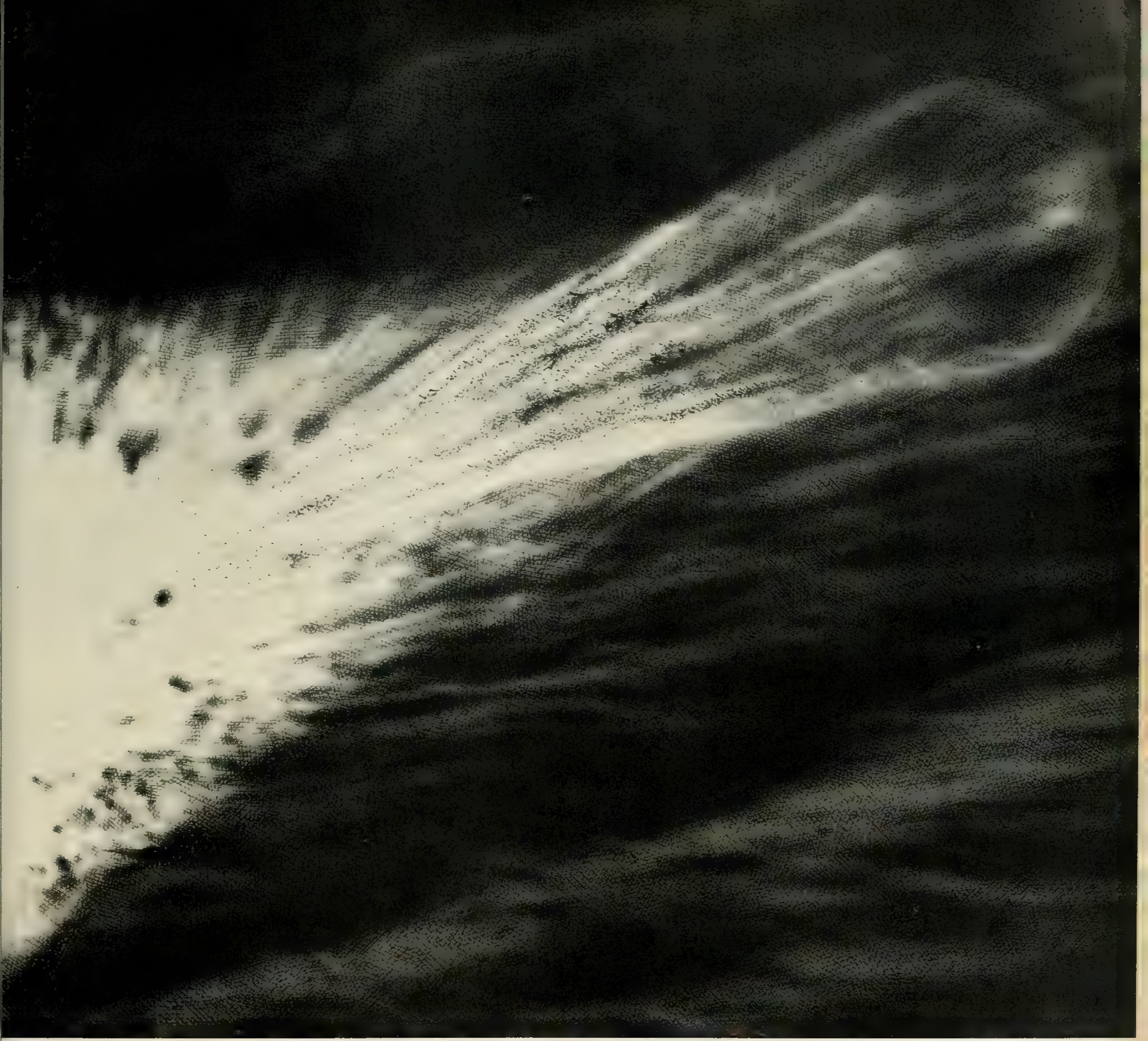
The latter two are related to the less potent threat posed by manned bombers and air-launched standoff missiles, but must be maintained and refined as long as an enemy possesses a second-strike capability.

Imminent introduction of the Bendix-built FPS-85 radar at Eglin AFB, Fla., will enhance the capabilities of SPADATS, which DDR&E scientists think is adequate for the foreseeable future. They do want further refinements, however, in the form of improved target analysis from the ground.

Information from BMEWS is also fed into SPADATS, and the potential foreseen for the classified over-the-horizon radar program will sharpen BMEWS. Over-the-horizon radar may also guard the "back door" left open by BMEWS, in that it might be able to detect an attack launched over the Antarctic—even though this route is considered by DDR&E planners to be beyond the Soviet state of the art.

DDR&E officials describe over-the-horizon radar as a "blunt instrument" in comparison with BMEWS, but it is expected to supplement BMEWS with its ability to detect an ICBM attack soon after launch—as soon as the ionosphere is disturbed. Sylvania and Raytheon Co. have study contracts for the over-the-horizon radar concept.

Another surveillance and control concept under study in the Office of Defensive Systems is AWACS (Airborne Warning and Control System). DDR&E has budgeted $9 million for systems studies in FY '65. Officials say the system probably would go aboard long-endurance aircraft. Chief advantage seen for AWACS is the ability of its radar to operate free from the clutter that hampers ground-based radars.



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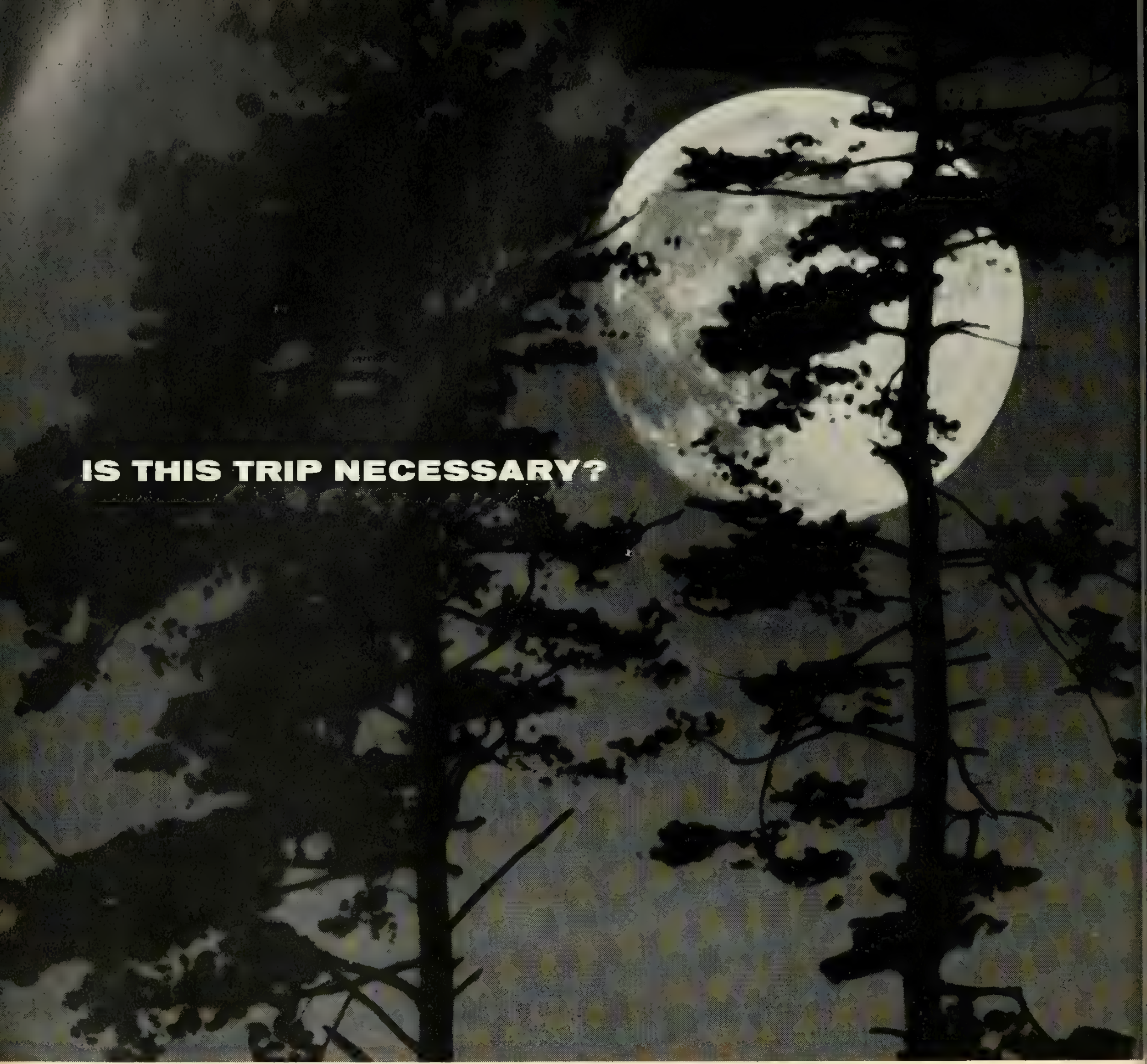

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• Active defenses—Turning again to the active defenses Fink's office has been watching closely, three as-yet-untested systems—exclusive of *Nike-X*—are expected to contribute to fulfilling the office's mission. They are NASA's *Gemini*, the Air Force's *MOL (Manned Orbiting Laboratory)* and the Army's *AADS-70 (Army Air Defense System, 1970)*.

DDR&E officials look to *Gemini* and *MOL* technology to enable them to cope with spaceborne threats, even though they don't consider such threats to be immediate. These systems could supplant the *SAINT (Satellite Inspector)* as an orbiting inspector and/or interceptor.

AADS-70 is in the feasibility-study stage. Radio Corp. of America, Hughes Aircraft Co. and Raytheon have study contracts for the weapon, each totaling about $700,000.

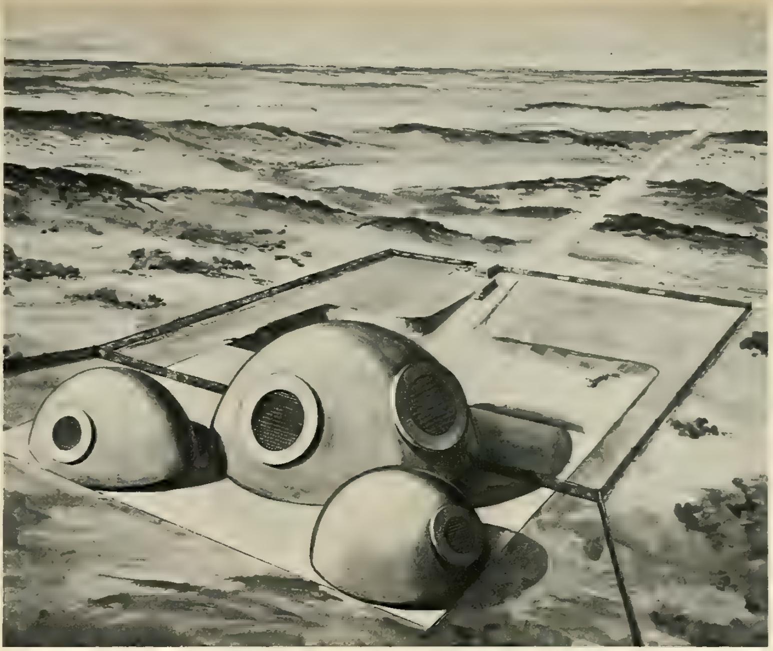
DDR&E planners told M/R they are seeking versatility in the system. They want it to be able to operate against both aircraft and short-range missiles—including sub-launched missiles—over a wide altitude range. They expect it to be useful as a field army weapon and also effective in a continental missile defense system.

• Typical Nike-X site—In the latter role, *AADS-70* might fit into the ultimately deployed *Nike-X* complex. Defensive Systems specialists draw this picture of a typical *Nike-X* "missile farm": The MAR radar, plus target-tracking radars; *AADS-70*, if such a system is procured; *Nike-Zeus* and possibly the *Nike-Hercules*; and finally the *Sprint*. The missiles would be in silos.

DDR&E spokesmen express almost absolute confidence in the silo system. They say it would be virtually impossible for an enemy to destroy more than one silo per attack. In other words, the enemy would have to score a direct hit to render a silo-protected missile inoperative. It would be extremely difficult to damage a silo just five miles away from the blast area, they say. This holds true for strategic as well as defensive missiles.

DDR&E strategic and defensive planners are also optimistic that *Nike-X*, if deployed, will be able to cope with sub-launched missiles. The short flight time of a sub-launched missile in relation to an ICBM is not expected to present problems because *Sprint's* planned acceleration could overcome the handicap of short warning time.

Nevertheless, since a complete, 30-site *Nike-X* system is some 10 years away, DOD efforts to defend against sub-launched missiles have been channelled into improved submarine detection, tracking and destruction before missiles can be launched.



MULTI-FUNCTION Array Radar appears in artist's conception. MAR, an advanced phased array, is being developed for the Army by Sylvania as part of the Nike-X complex.

Two Navy programs—Trident and Artemis—attack the submarine-detection problem. The latter has been described by Secretary McNamara as "a large-scale experimental effort in the long-range active detection of enemy submarines . . . directed at extending our basic knowledge of sonar techniques. . . ."

In addition, according to McNamara, selected air defense radars on the East, West and Gulf Coasts have been modified to give some capability against sub-launched missiles.

Assuming success in the Trident and Artemis studies, plus the additional detection capability offered by modified air-defense radars and successful *Nike-X* development, McNamara concluded his House Armed Services Committee testimony regarding ICBM's and sub-launched missiles by saying "The *Nike-X* system, if we decide to deploy it, would then provide the primary capability against submarine-launched missiles."

Nobody at DDR&E is recommending anything beyond *Nike-X* as a mainstay defense against ICBM attack.

• Civil defense considerations—But McNamara said in a recent press conference that he would not recommend deployment of *Nike-X* until the U.S. had an adequate number of fallout shelters. This is why discussion of anti-missile defense involves the office of Steuart Pittman, Assistant Secretary of Defense for Civil Defense.

Because of the nature of the *Sprint* concept, protection from fallout is critical before the system can be used. Martin Co. is prime contractor for the weapon, Hercules Powder Co., and Lockheed Propulsion Co. are propulsion contractors, and Western Electric Co. is responsible for guidance.

Sprint would engage enemy ICBM's at relatively low altitudes—less than 150,000 ft., according to DDR&E officials—to allow the atmosphere to strip away decoys and to permit identification of the re-entry vehicle by defensive radar. This means a successful intercept would cause considerable fallout, possibly killing countless unprotected persons even though the re-entry vehicle hadn't penetrated the defense.

McNamara's posture statement before the House Armed Services Committee envisioned 240 million fallout shelter spaces by 1970 to protect the entire U.S. population at home and at work. His FY '65 budget requested $190,600,000 for significant advances in the shelter program. The entire "survival package" eventually would cost between $3 and $4 billion, say DDR&E officials.

The FY '65 funding was approved by the House Armed Services Committee, voted by the House, then sidetracked by a Senate Armed Services subcommittee chaired by Sen. Henry M. Jackson (D-Wash.). The subcommittee shelved any FY '65 progress in a fallout shelter program by deferring funding—probably until next year. The action could delay a DOD decision to deploy *Nike-X*, since McNamara wants a going shelter program first. ■

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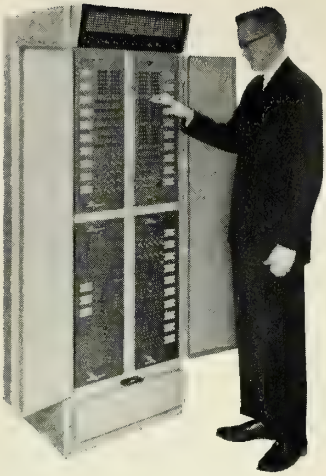

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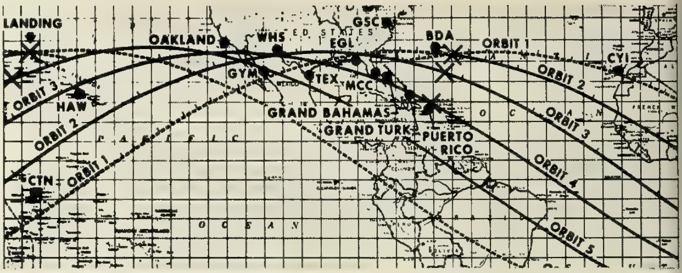

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Strategic Office Stresses Product Refinement Moves

Completely new weapons won't be needed even if Soviets develop 'effective' ABM

TYPICAL OF ABRES program is the study of radar cross-section characteristics, and ways to reduce them. Scale model of a re-entry vehicle is shown in Douglas Aircraft Co.'s anechoic chamber to determine reflective radar energy from test specimen. Such programs are aimed at better penetration aids for ICBM's.

PRODUCT IMPROVEMENT—rather than development of completely new systems—is the outlook for Strategic Retaliatory Forces during the foreseeable future.

Major new systems requiring the development of a complete new weapon will not be required even if the Soviets deploy an "effective" anti-missile defense, DDR&E officials strongly emphasize. They are not willing, however, to concede that the Soviets will, or can, deploy an anti-missile system which would be truly effective against the U.S. retaliatory force.

With $500 million still to be spent on development of *Minuteman* through Fiscal Year 1969, DDR&E officials point out that "as far as a weapons system is concerned, we are still in the middle of *Minuteman*. We haven't really started development testing and operational testing of Wing VI (*Minuteman II*). "With that much money and work still to be performed, one DDR&E official candidly admits that "it is hard to get excited" about the lack of a replacement system for *Minuteman* or *Polaris*.

Both the Navy and the Air Force have limited funds ($5-15 million) for studies and some component development for advanced ICBM's—or, in Navy parlance, Advanced Sea-based Deterrent Systems. However, neither service is likely to get permission to start full-scale development of any such system as long as the present power structure exists in the Pentagon.

The only real need in the Strategic Retaliatory area, according to one DDR&E official, is for a "long-range, multipurpose, multicrewed, ZI (Zone of the Interior)—based aircraft." However, another official disputes this. "The Advanced Manned Penetration System (AMPS) which the Air Force proposes as a one-for-one replacement for the B-52 would be nothing more than a gigantic TFX," he declares. He adds that it would, like any aircraft, be constrained to "going to one place," whereas a missile can be retargeted.

- **Soviet ABM, so what?**—DDR&E officials feel that a Soviet antiballistic missile, if deployed now, probably would not be as sophisticated as the Army's *Nike-Zeus*. Present penetration aids can defeat *Zeus*, therefore a Soviet ABM of this type would not be a major threat.

If, however, the Soviets deployed an "effective" ABM system—and nobody wants to define what would constitute such a system—both of the major U.S. deterrent systems, *Minuteman* and *Polaris*, have sufficient growth potential to allow the U.S. to defeat the ABM without an entirely new missile system.

Studies conducted by the Dept. of Defense have clearly illustrated that penetrability is directly related to payload weight. Consequently, in the Soviet ABM situation, DOD would definitely be interested in heavier-payload missiles. These would carry advanced penetration aids—perhaps in combination with multiple warheads.

These heavier payloads would be achieved by increasing the diameter of both *Minuteman* and *Polaris*. Secretary McNamara has already expressed interest in the *Polaris B3*. This missile would have, in addition to other improvements, a diameter increased from 54 to 56-57 in., principally by a reduction in thickness of the liner in the missile tube (M/R, Feb. 24, p. 16; M/R, Jan. 13, p. 18).

The Air Force has also conducted studies which reveal that larger-diameter missiles could be retrofitted into *Minuteman* silos. These missiles, which would rely on the technology of the *Titan III* 120-in. solids, would increase the payload capability of the *Advanced Minuteman* "by at least four times."

"There is not much incentive to do this now," a DDR&E official says, "and the major incentive would be related to the Soviet's active defense."

Meanwhile, two important product-improvement decisions have already been made with regard to the *Minuteman II*.

—Improvements will be made in the guidance and control system to significantly improve the initial system's accuracy. This program will be carried out over the next several years.

—An improved re-entry vehicle enabling the *Minuteman* to penetrate any forseeable defense will be introduced into the program within several years. The re-entry vehicle is the Mark XII under development by Avco.

With the FY '66 budget, the *Minuteman* retrofit program will begin and continue over the next five years. *Minuteman II* missiles will be back-fitted into the first five wings, and the entire *Minuteman* system will be modernized.

- **Another road, more accuracy**—Accuracy of both *Minuteman* and *Polaris* has been improving steadily. In fact, one DDR&E official terms the accuracy improvements "phenomenal." Even further improvements are possible in the present guidance and control systems without developing an entire new system.

Future guidance schemes are under consideration, however, and development of components is being funded. These developments fall into four major areas:

—Inertial guidance during boost;
—Inertial all the way;
—Inertial and terminal guidance; and,
—Inertial and radio vernier.

A great deal of interest and emphasis is being placed on the inertial-with-terminal-correction capability. The main problem with the maneuvering re-entry vehicle, however, is that the guidance components must be able to withstand the high acceleration forces encountered in coming back into the atmosphere. Terminal schemes will have to wait until the possibilities of improving internal systems in present systems have been exhausted.

Basically, the search for higher accuracy is the technical implementation of Secretary McNamara's "damage-limiting" strategy. The major goal is dual: to gain a higher confidence of destroying military targets of a particular hardness and, at the same time, to reduce the yield of the warhead so as to minimize collateral damage.

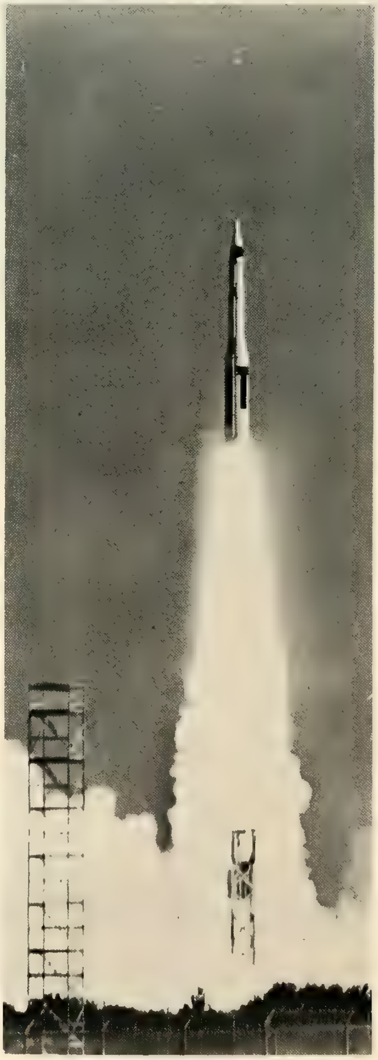
- **Getting through**—One of the biggest missile R&D programs is the *Advanced Ballistic Re-entry Systems* (*ABRES*) program to insure that ballistic missiles will be able to penetrate whatever defensive systems they encounter. Development of re-entry vehicles for operational systems does not fall under this program, but rather is funded under the specific system.

The *ABRES* program is divided into three major areas:

—Advanced Re-entry Technology;
—Range, instrumentation and data processing; and
—Test vehicles and launch support.

A joint Air Force-Navy project office controls *ABRES* and cooperates to the maximum extent with the Army and ARPA. The high expense of the program is made more palatable by the fact that results of the tests feed directly into both the *Nike-X* and Defender programs as much as into the strategic missile areas.

FRED A. PAYNE, JR., Deputy Director, Strategic and Defensive Systems.



MINUTEMAN ICBM blasts off from Cape.

A great deal of progress has been made during the past three years, particularly in improving knowledge of the physical effects resulting from a warhead re-entering the atmosphere and of the methods with which to simulate these effects. In fact, DDR&E officials note that penetration-aid packages are becoming available now—an extremely short gestation period for a program of this magnitude.

A national program, *ABRES* depends to a large degree on system analysis in which different penetration systems are continuously analyzed and wargamed against various kinds of defenses. Use is also made of foreign technology as an indication of possible approaches in the next 10-15 years.

Possible penetration techniques under development include reducing the vehicle's cross section so that it becomes "invisible" to the enemy's sensors whether they be radar, infrared or optical.

The next area of interest is the active devices—such as chaff or electronic countermeasures packages—which obscure the re-entry vehicle. Decoys which have the same reflective characteristics as the re-entry vehicle can also be used. However, once the re-entry vehicle penetrates the atmosphere these decoys are quickly separated from the warhead, thus relieving the discrimination problem.

Two final areas of interest are: 1) hardening of warheads so that they can withstand the defensive weapon effects and 2) using multiple warheads to saturate the defenses so that the enemy cannot react fast enough to destroy all the re-entry vehicles.

Terminal guidance would increase penetrability considerably by increasing the threat tube—the theoretical volume within which a re-entry vehicle must approach in order to destroy a target—by targeting the re-entry body to fall short of the target, and then through a terminal maneuver pulling it up and into the target. This is a further dividend—quite apart from increased accuracy—accruing from maneuvering re-entry bodies.

One of the major programs aimed at bettering knowledge of re-entry phenomena and applying this knowledge to improved re-entry vehicles is the *Athena* program being conducted by the Air Force from Green River, Utah. The program, involving more than 70 flight vehicles, started last month, but immediately ran into trouble when the first vehicle was brought down within 20 miles of Durango, Colo. (M/R, Feb. 17, p. 10).

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Range at a controlled re-entry velocity, angle and altitude, the package can be monitored by the range's ground-based and airborne instrumentation. One of the purposes of the *Athena* program is to develop scaling laws for ICBM re-entry vehicles which will allow data from tests of models to be extrapolated to the full-scale vehicle without actually having to build and flight-test the bigger model.

Pre-launch survivability plus the ability to ride out a missile attack and still retaliate is a continuing effort under the various ballistic missile programs.

- **Command and control**—This topic, an integral and important part of the strategic retaliatory forces, still causes concern within DDR&E, although important advances have been made (see story on pp. 79-84). The area of main concern is the need for, and extent of, a post-attack command and control system.

Two of the major improvements being made in command and control of the strategic retaliatory forces are the integration of *Minuteman I* and *II* into a single system and the new fire control system being introduced into *Polaris* submarines.

Minuteman effectiveness will be stepped up through the internetting of the *I* and *II* missile communications system—thus enhancing the targeting flexibility of the entire force. The *Polaris* fire control system will also improve the targeting capabilities of each submarine. *Minuteman* flexibility will give it a greater choice in the selection of pre-assigned targets, as well as the capability of being launched on command from an airborne command post.

- **Reliability and dependability**—A major portion of the *Polaris* and *Minuteman* forces—10% in the next 18 months and a similar percentage over the next five years—will be expended to insure operational dependability of the strategic retaliatory force. (M/R, Mar. 16, p. 11).

Dependability is a broader term than just reliability. It includes reliability (incidence of mechanical malfunction), as well as readiness, survivability and penetration. Operational readiness tests with both *Minuteman I* and *Polaris* submarines on patrol have established that a very high percentage of the missiles were ready to launch at all times. By contrast, it is estimated that slightly more than 50% of the B-52 force can be maintained on 15-minute ground alert at any one time.

The hardened and dispersed ICBM force and the submerged *Polaris* subs would present the enemy with much more difficult targets than aircraft. A single ICBM impacting on a Strategic Air Command base would be sufficient to destroy all the aircraft caught on the ground. Some undoubtedly would survive, but how many is difficult to predict. This is reflected in the widely varying survivability rate applied to the bomber force vis-a-vis *Minuteman*.

The third factor—the ability to penetrate—is not a big question mark when applied to strategic missiles but does present a wide range of uncertainty for manned aircraft. The Soviets have developed and deployed extensively air defenses in depth around their major target complexes.

As Secretary McNamara puts it, "As a result of our penetration aids and numerical superiority, we can be sure that once our missiles are launched and on their way they would destroy their targets. There is greater uncertainty about the proportion of the bombers that will get through because of the extensive Soviet air defenses. We believe that the proportion will be high, but there is a substantial range between the optimistic and pessimistic figures."

Mechanical reliability is being insured through extremely tight component specifications. The *Minuteman* reliability program has achieved, at considerable expense, components with the highest design reliability. The severest qualification test program has also contributed to this reliability program.

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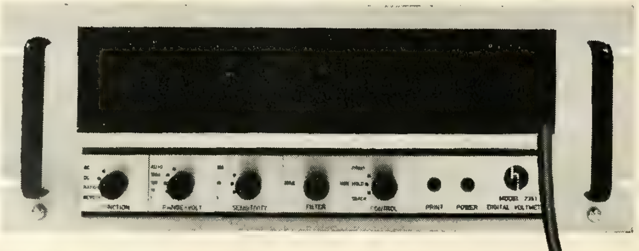

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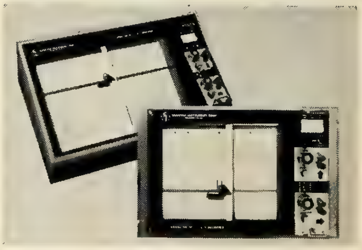

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tional experience, over 23 billion operational component-hours have been amassed on the electronic parts in the *Minuteman* missile and ground-control environment. So successful has been this program that DOD has undertaken a program to make technical data on reliability tests of components available to industry and the rest of DOD through the Interservice Data Exchange Program (IDEP).

So important is reliability that it is a major consideration in proposed changes to the retaliatory systems. "Our experience has clearly shown that we should initiate new long-range missiles or major changes in existing ones with extreme care," Director of Defense Research and Engineering Dr. Harold Brown told Congress recently. "Expensive qualification test programs are needed for new systems, and any changes unless carefully controlled can delay assurance of systems reliability. The corresponding improvement in capability represented by such changes must therefore be quite large in order to offset the interim degradation and justify the special qualification tests."

- **Strategic force levels**—By June of this year, strategic missiles will reach parity with manned aircraft. From then on the emphasis will definitely have shifted. The B-52 force will be continued over the projected five-year period, 1965-69, at 630 aircraft. All but 200 of the B-47's will be phased out by the end of Fiscal '65 and the remainder will be gone by the close of the following year, with the possible exception of some reconnaissance aircraft. The latter will depend on the RC-135 operational schedule.

The B-58 force will continue through the period, with reductions in aircraft through attrition. There are some 98 B-58's in the operational inventory. *Hound Dog*, primary armament for the B-52, will also be continued throughout the five-year period.

The strategic missile force, which tripled in FY'63 and will double again this year, will increase more slowly during the Fiscal '65-69 time period. Only 50 new silos will be added to the *Minuteman* force, bringing it to a total of 1,000 missiles with an eventual total planned force of 1,200. This amounts to 50 new silos a year over FY '66-69. Most of the new *Minuteman II* silos will be co-located with the first five *Minuteman I wings;* only the first *MM II* wing will be separately sited.

DOD has decided on a faster rate of retrofit of *Minuteman I* with *Minuteman II* rather than a faster build-up of the advanced model with slower retrofit.

The first *Atlas* missiles (all the *D* models and some *E* versions) will be retired from the inventory in Fiscal '65. Some 27 weapons will be scrapped, and the rest of the *Atlas* force and the *Titan I*'s will follow during succeeding fiscal years. No plans for phasing-out *Titan II's* have been announced, but it is likely that these 54 missiles also will leave the arsenal during the projected period.

The entire 41-boat *Polaris* submarine program was funded with Fiscal 1964 money and no additions to that force are planned. The Navy has launched 19 submarines; 11 of these are on station. Present plans are to outfit boats 6 through 18 with *Polaris A2* missiles and 19 through 41, as well as one through five, with the longer-range *A3* when it becomes operational in August.

The entire *Polaris* force will become deployable by the end of Fiscal 1967. Replacement of the *A2* with the *A3* will not be necessary for a number of years, according to Secretary McNamara. Part of this postponement results from DOD interest in the *B3* program, but budgetary factors apparently are responsible for most of the delay. The Secretary estimates that some $425 million can be saved by postponing the *A2* retrofit program.

Finally, three *Regulus* submarines will be phased out of the inventory during FY '65. These subs carried eight missiles. Two other *Regulus* subs will be continued in the inventory for another year, with nine missiles aboard. ■

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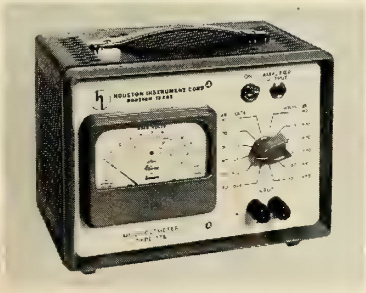

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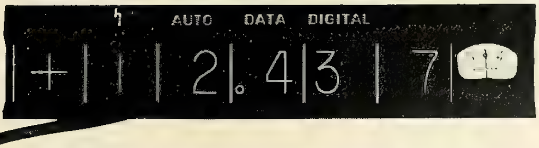

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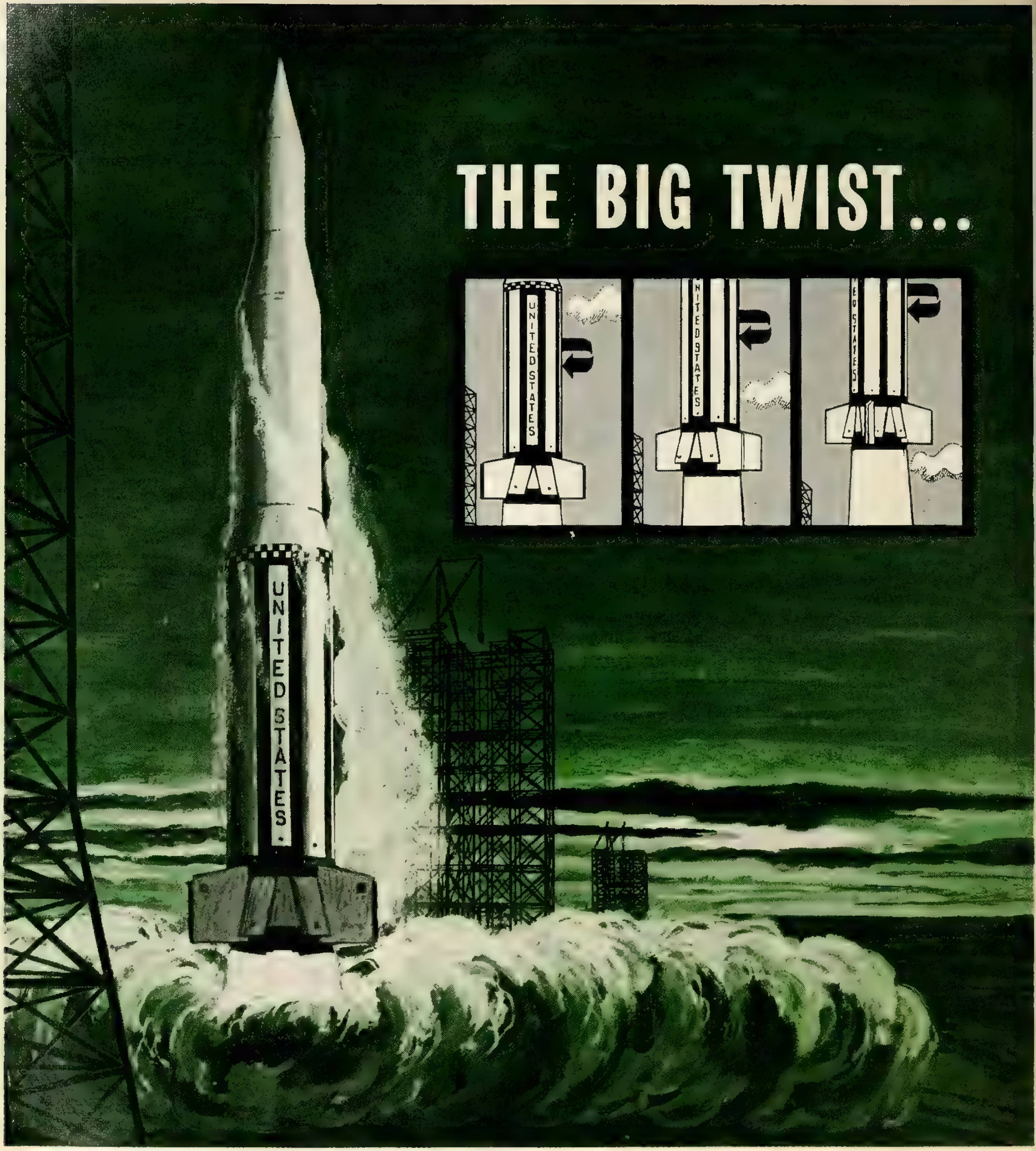

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Military Space Planners Insist MOL Program Not a Race

Unmanned missions to get emphasis in next two years; 1975 established as target for operational manned capability

THE U.S. MILITARY space program, while preparing to meet the possibility of a manned operational capability by 1975, will continue to emphasize unmanned missions for the next two years.

At the same time, DDR&E officials do not expect any large rise in military space funding over the Fiscal Year 1965 level of $1.5 billion. In fact, they do not foresee funds reaching $2 billion per year in the future.

This assessment of the effort will hold true, the officials contend, even if the Air Force's *Manned Orbiting Laboratory* (*MOL*) program is given the development go-ahead later this year.

While many high Air Force officials voice misgivings about making changes in *MOL*, DDR&E declared that the decision has been made that there will be a program.

"We realize that there has been apprehension among some people. It stems from the fact that after the program was announced in December, 1963, we didn't race off to start development," the official said.

Instead, a six-to-nine-month study effort was ordered to determine what the *MOL* program would enable man to perform in terms of military missions.

- **Not a race**—In defense of their action, DDR&E officials declare that the *MOL* program is not a race. "It is an experimental program and we need to take the time to insure that it is well planned before we commit ourselves to a lot of hardware," they said.

MOL will not mean a sharp rise in the DOD space budget, according to the same officials.

They point out that funding for the *Titan III* booster has reached its peak in FY '64 and will now begin to taper off. At the same time, money earmarked in earlier planning for the cancelled *Dyna-Soar* program will be switched to the *MOL* effort.

Most importantly, one of the guidelines laid down by DDR&E for the *MOL* program is that it should not require the development of a lot of new subsystems.

Officials refuse to say when contractors may be selected for the *MOL* development program—or even if it will have a program definition phase. Also unknown at this point is whether a prime integration contractor will be required.

All these things, DDR&E reports, will be decided by the Air Force after the current study period. One thing is certain—no contractor action, even program definition, is expected until late this year or early next year. This is also certain to force some slippage into the late 1967-early 1968 launch dates announced for *MOL*. The first launch now may not be made until a year or more later.

The lack of decisions or any sort of an official timetable for the program adds to the pessimism felt by some Air Force officers and other U.S. space experts as to whether *MOL* will ever move to the development stage.

- **Pre-emption?**—A recent move by the joint NASA/DOD Aeronautics Coordinating Board is adding to the shadows surrounding the project. A subpanel was set up to determine the optimum configuration for what is called the National Space Station Program. Their report is expected before the end of the year.

DR. ALBERT C. HALL, DDR&E Special Assistant for Space Programs.

It is just possible that they may recommend a space station which conceivably could fulfill DOD's *MOL* requirements as well as serve as a building block to a larger station sometime in the future. Such a recommendation could mean the end of the *MOL* project.

- **Other interests**—*MOL*, however, is not the only new development project looming on DDR&E's horizon. Other projects currently being given serious study include:

—A new high-energy upper-stage program will move to the preliminary engineering design stage in FY '65. DDR&E officials believe that the stage will be required for the *Titan III*. Fluorine as well as storable hydrozene oxygen is being studied. A decision whether to initiate development will be made in about one year. Since NASA is also studying possible development of such a stage, a joint agency decision as to who will direct the program must be reached before a start can be made.

—If a manned military space operational capability is part of the U.S. defense posture in 1975, DDR&E believes a winged logistics and re-entry vehicle will be required. With seven years' lead-time needed to develop the vehicle, a start would have to be made in the 1966-67 period.

—A prime contractor will be selected before the middle of next year to develop a Standardized Space Guidance System under a contract with a potential worth of many millions of dollars. Four contractors were selected on Jan. 29 for a four-month Phase IA, which is the preprogram definition of the system which it is hoped will fill all DOD guidance requirements through 1970. Phase IB calls for two contractors to perform a feasibility demonstration. Phase II will be the selection of one contractor to develop a flight system starting in the middle of next year.

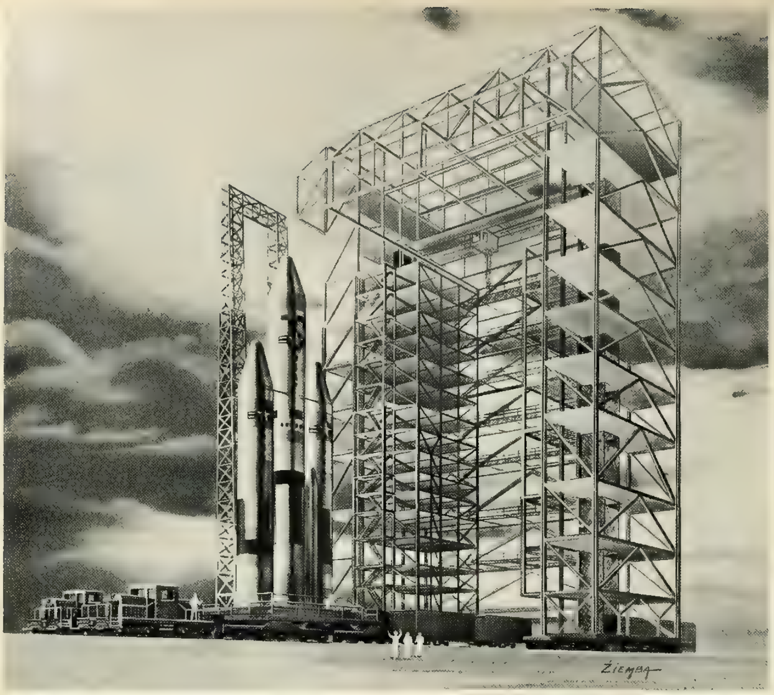
—DDR&E will continue with the 156-in.-dia. solid motor program. At this point, there is no military requirement for the large solid and DDR&E is not considering any military application for it.

—Research will continue into a high-pressure liquid engine with a thrust greater than NASA's 1.5 million-lb.-thrust M-1 engine. DDR&E, however, does not see any military requirement at the present time for a liquid engine of that size.

—A start on a medium-altitude communications satellite for DOD is being delayed until it can be determined whether an agreement can be reached with the Communications Satellite Corp. to fill DOD requirements. An interim decision is expected between April 15 and 30. Six more months of negotiations are expected before a final decision will be made.

- **Prime decision**—The principal task facing DDR&E in the next couple of years will be to determine whether a manned military operational capability must become part of the U.S. defense establishment.

In order to make the determination, DDR&E last year announced the initiation of the *MOL* program to serve as



INTEGRATE-TRANSFER-LAUNCH (ITL) complex is a key part of the Air Force Titan III. ITL at Cape Kennedy will, for the first time, permit complete assembly and checkout of a space booster, payload, associated ground equipment and launcher in a controlled, factory-like environment. Titan III-C is seen here.

NASA Joins in Space Station Report

DDR&E and NASA are preparing reports that will recommend the best approach for a national space power project and a national space station program.

The two agencies—through the joint Aeronautics and Astronautics Coordinating Board (AACB)—are also preparing a study of just what range and tracking equipment has been developed and how the two agencies' systems can be made more compatible.

The AABC is co-chaired by Dr. Harold Brown, Director of DDR&E, and Dr. Robert C. Seamans, NASA Associate Administrator.

The study of the best configuration for a National Space Station is perhaps the more important current task. A special sub-panel of the Manned Space Flight Panel has been established to do the job.

Expectation among board members is that the report will be completed in the last half of the year.

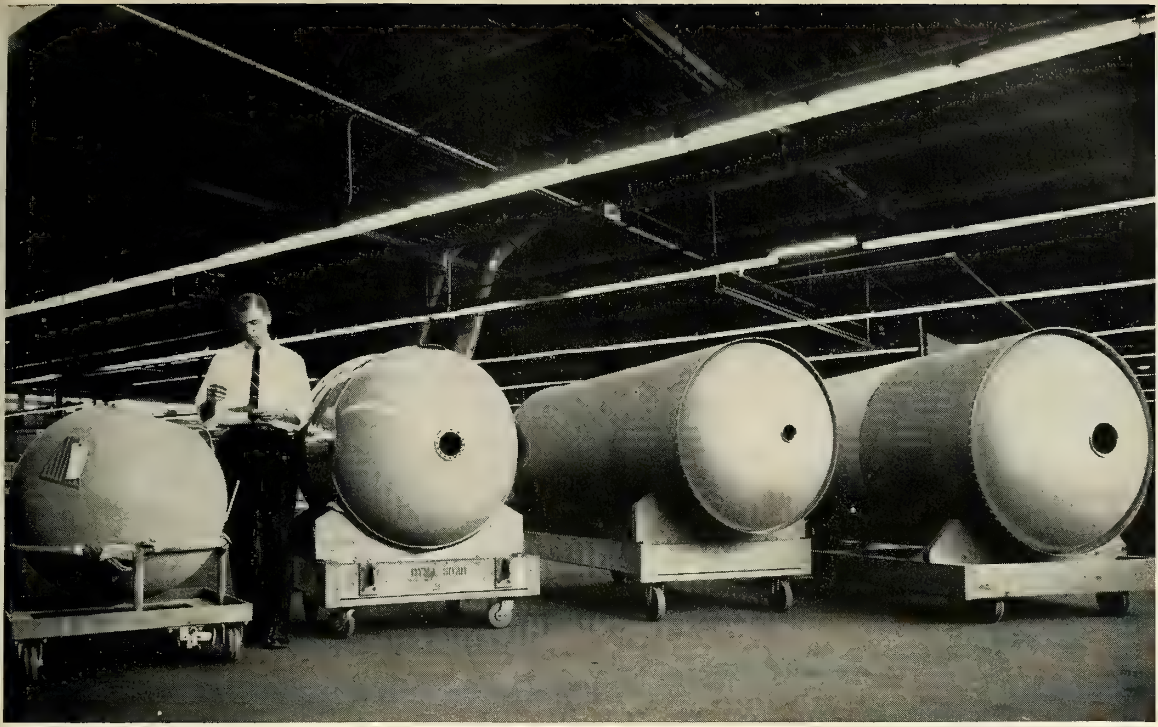
The sub-panel is also charged with coordinating space station study contracts of both NASA and DOD. It will also be responsible for optimizing use of existing hardware in the space stations as well as recommending the agency to direct the project.

The supporting research and technology panel is also engaged in an important study of the various space powerplants being developed, including fuel cells, batteries, solar cells and the various nuclear power systems.

The group will compile information on all existing programs and compare it with requirements of known and projected space missions. If they find that the space power program is not in step with the requirements of the U.S. space program, they will recommend changes.

The sub-panel's report is due by the middle of June. It is headed by Walter Scott of NASA and Air Force Lt. Co. Lew Allen.

The board is also now engaged in attempting to increase joint use of NASA and DOD tracking facilities. Details of the report are still being worked out.



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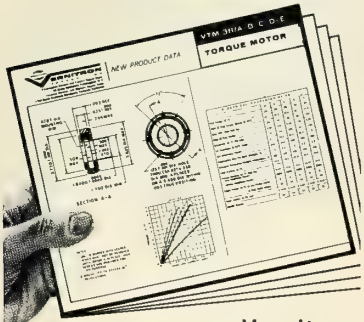

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a test facility to study just what military tasks man could perform in space.

The guideline set for *MOL* by DDR&E was that it must be an orbital test facility for two or more crew members, providing life support in a shirt-sleeve environment, tests of approximately 30-days duration, and capacity adequate for simultaneous operation of multiple mission equipment.

The equipment also has to be accessible, so that man can adjust, calibrate and, in some cases, repair them. It must also be accessible in the sense that a man may move from one system to another to utilize or operate them—for example, checking an IR presentation with an optical viewer.

Another requirement is the capability to select alternate mission modes, so that the astronauts can select the combinations of sensors and other systems calculated best-suited for whatever task he is engaged in. Finally, the in-space test facility has to be designed, from the outset, to stress man's active participation at all times as a key element in a man-machine loop performing in-space data collection, processing, evaluation, filtering and disposition.

● **Major goals**—The five basic objectives of the MOL are:

—It has to provide a minimum essential in-space test facility at an early date.

—The functions to be performed should provide a measure of man's usefulness and be preceded by aircraft and ground simulation tests.

—Requirements are to be met wherever practicable with equipment currently under development, and the approach selected has to show minimal developmental and operational risks.

—It has to have a reasonable, attainable program schedule and a commensurate fiscal commitment.

—Finally, DDR&E feels that any approach selected should provide a basis for orderly growth—if future needs develop and man's utility is demonstrated.

● **First outlines**—*MOL's* current configuration calls for a modified *Gemini* capsule coupled to a pressurized laboratory cylinder of approximately 1,500 cu. ft. of volume configured as an orbiting laboratory, to be launced integrally on a *Titan III-C*. Astronauts will be seated in the *Gemini* capsule during a launch and will move into the laboratory after injection into orbit.

After completion of their tasks in space, the astronauts will re-enter the *Gemini* capsule, detach and de-orbit, leaving the laboratory cylinder in orbit.

The *Gemini* capsule is being developed by NASA for support of the lunar program and will be modified no more than is necessary to meet the

MOL Tracking Requirements Awaited

DDR&E expects to complete its first estimate of the *Manned Orbiting Laboratory (MOL)* program tracking requirements in about six weeks.

At this point, officials told MISSILES AND ROCKETS, no determination has been made as to how much, if any, new equipment will be required.

One difficulty is that equipment being developed for NASA's *Gemini* and *Apollo* manned space flight programs is not compatible with Air Force systems. While nothing has been said officially, the impression left by officials is that the Air Force would like to use equipment that can transmit to their stations.

DDR&E scientists are also making an assessment of the number of tracking stations really required by the military's space and missile development programs.

Deadline for completion of the study is Apr. 1, 1964. The first estimate is that some of the tracking stations in the Pacific will be closed down. One report indicates the cutback in sites may include some Air Force managed stations in the Hawaiian Islands.

DDR&E's tracking office is also continuing its studies of long-term technical problems that they feel must be solved.

One is the ability to measure space vehicle position velocity, which has not kept pace with requirements over the past five or six years. A brute force approach is presently being used to solve the problem through a broad range of studies. The need is particularly acute for programs involving vehicles that are required to maneuver after second or third-stage burning.

Current equipment does not make accurate enough measurements.

Another major problem is the inability to make accurate re-entry measurements for ballistic missiles. Officials report that many missile programs are well along in the development cycle before engineers working on them have the benefit of good re-entry data.

Two trends already noted by DDR&E include the use of satellites to relay tracking data in the mid-1970's and the use of more "off-shore" computers to reduce the amount of data coming back to stations.

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MOL needs. While not required in the early stages of the program, rendezvous provisions will be designed into the *MOL* so that the laboratory can later be resupplied and reused if justified by progress made in defining man's military role in space.

- **Future trends and objectives**—DDR&E continues to explore possible requirements for new space systems in a variety of areas. These include ballistic missile early warning, in-space inspection, identification and classification of satellites, ballistic missile defense and antisubmarine warfare.

In all these areas, however, DDR&E still is trying to determine if space systems are feasible or whether the requirements can be better fulfilled by ground-based systems.

The long-term objectives of the U.S. military space program now include:

—A trend toward use of well-tested, "standardized" subsystems for all operational spacecraft—designed to provide lifetimes and coverage which properly balance delivery costs and replacement with advanced versions, and packaged to fit the capacity of an accepted family of launch vehicles.

—Implementation of an orderly series of steps to minimize the number of DOD launch vehicles employed and avoid the reliability problem inherent in proliferation.

—A careful evaluation of military man's potential for performing missions in space, and the laying of the groundwork to move effectively in any area where promise is indicated and requirements justify it.

—Research and development by means of unmanned vehicles in supporting maneuverable re-entry vehicles.

—Maintenance of a strong and vital supporting research and technology effort. It is likely that this effort will remain at about FY 1964 and 1965 funding levels through 1970. Basic objectives will include the following:

Satellite lifetimes of greater than one year for payloads containing more than 10,000 active components and capable of performing complex functions.

Proven techniques for long-term satellite stabilization (gravity-gradient or other) at low, medium and synchronous altitudes.

Long-duration electric power supplies, radioisotope or solar, at power levels 1 to 15 kw.

Proven capabilities for each launch vehicle to be reflected in launch success ratios greater than 0.85.

Progress toward recoverable boosters to reduce launch costs.

Development of maneuvering upper-stage capabilities.

An across-the-board improvement in sensor capabilities. ■

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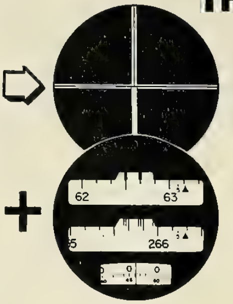

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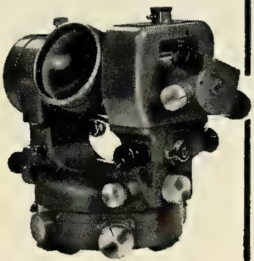

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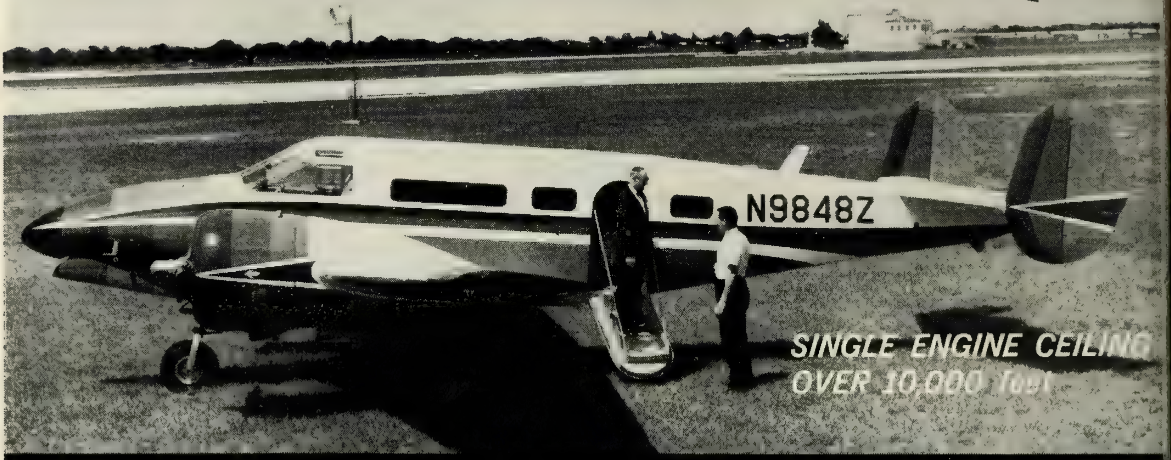

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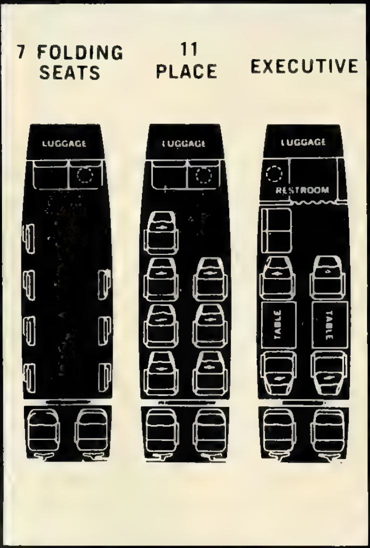

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Command & Control Reorientation To Handle Flexible Response Policy

Systems must be versatile enough to cope with situations short of massive retaliation; war-gaming tests adequacy

THE MAJOR REORIENTATION of U.S. command and control (C&C) systems to better serve the needs of military commanders under a national policy of controlled flexible response is now unofficially in its second year. While virtually everyone concerned with this sector of the nation's defense structure agrees that improvements have been wrought, it is also widely acknowledged that it is a difficult kind of success to measure.

The heavy emphasis on C&C is eating up large chunks of Defense Dept. dollars. (The office of the Director of Defense Research and Engineering requested $141.2 million in FY '65, up from $70.2 million in FY '62). This, combined with the fact that it can no longer be assessed by weapons system yardsticks as it was in the past, adds up to "some current uncertainty as to just what we're accomplishing," as one top C&C advisor puts it.

At the root of both the improvements to C&C systems and thinking, and the cause of the uncertainty, is the realization within the past few years that the hardware development aspect of C&C had far out-stripped the attention paid to the so-called "software" aspects (M/R, Dec. 3, 1962, p. 16).

This became even more critical when viewed in the light of the new demands of flexible response in comparison to the earlier massive retaliation philosophy. While one cannot function without the other, it is the software which seeks to define not only the programs, but the basic command functions of any C&C system and its real ability to aid the commander.

Where C&C in its earlier stages tended to be viewed and developed as specific systems with associated definable hardware, it is now viewed far more as a broad evolutionary management function dealing in the first place with the less tangible elements of command definition and management structure in the control of forces.

While cost-effectiveness could be applied to some of the earlier package-type C&C systems, such as the Strategic Air Command's 465L system, to get a measure of value just as with a weapon system, the technique will not work with new C&C concepts, say DDR&E scientists, except for perhaps certain portions of the system such as survivable communications nets. What has replaced cost-effectiveness as the test-bed for C&C is the scenario or war gaming approach.

Underlying all of the newness now attached to software and progress assessment is the basic fact that this country does not have any really hard experience as to the demands that will be placed on C&C systems and on the top command levels in the event of, or threat of, a major war.

• Cuban crisis test—The one exception has been the lesson of Cuba and the October, 1962, missile crisis. U.S. C&C planners admit they learned a great deal then. Though they learned about the problems of space (or lack of it in U.S. command posts for persons whom they now know should have been there but whose offices had been previously set up elsewhere), they also learned "a lot about people's reactions."

This type of input is invaluable, planners stress, since "it is very hard to wargame the seat of government." While the U.S. ability to posture its forces quickly held up during the Cuban crisis, the situation itself has fed the development of "crisis management" techniques within DDR&E to a point where it is said to be one of the largest (not in terms of funding) areas of study.

It is aimed at improving the nation's ability to use our armed forces as a major instrument of national policy, and based in many cases upon the belief that nuclear war is not likely; a view held by more than one top DDR&E planner. "What experience has told us is likely," officials say, "is that crisis after crisis will be upon us."

Current U.S. C&C activity is being influenced by three major actions: 1) the continuing development of the National Military Command System (NMCS) as the means to tie the top executive branch and military levels to the string of military commands and supporting agencies; 2) a re-organization within DDR&E which, in effect, shifted NMCS from line to staff supervision and also created a small office for combat C&C that could ultimately become one of the largest areas of new development; and 3) a DOD directive issued in October that put teeth into the proposal that military commanders up and down the line be placed in better position to influence the requirements for improving current and future systems.

• Improving the existent—The concept behind these actions, all of which are related, is essentially to draw together the U.S. C&C effort to provide the most significant command inputs at the highest levels of government while constantly improving the systems either already in existence or under development.

There is currently very little intention of adding new long-range systems. As one top advisor told MISSILES AND ROCKETS: "We are not now interested in putting large sums into far-out programs. We are insisting that people do their best to improve what we have now."

DDR&E officers also claim success in building up the long-sought-after in-house C&C staffs both within their own offices, the armed forces' staffs, NMCS technical support agencies, the Defense Communications Agency, and the Advanced Research Projects Agency; in addition to already established support within the non-profit Mitre Corp. and Systems Development Corp. The result, DDR&E officers say hopefully, will be "future contracts that are highly defined and will therefore cost the DOD less. In the definition process, we are also likely to involve more firms than we did earlier."

DR. JAMES M. BRIDGES, DDR&E Special Assistant for Command & Control.

Basically, the evolutionary approach to C&C involves both addition of some new equipments to existing systems to improve or simplify them, and the development of new systems in increments or stages. This gives the commander the basic tools and then lets him learn how best he can solve some of his problems, rather than taking the old route, which takes a couple of years before you have something. Also, one official adds, "we no longer will use command centers to shake down new hardware."

• Spreading the work—What all this means is that the days of the packaged "L" system—where much of the lead-taking in concept, programming, and hardware design was often done outside the DOD—are all but over. Though this will mean fewer very large contracts for individual companies in this business, according to DDR&E officials, it will also mean much new C&C component hardware business over the next several years "with far fewer trenches and probably a lot more companies involved than in the past."

Some systems, such as the 438L Strategic Air Command intelligence system, according to DDR&E officials, "started out on the old weapons system development approach and got caught and put on an evolutionary basis." A major new system now under development, the 492L STRICOM (Strike Command) started out on the new philosophy.

Other systems, such as the AF's 481L post-attack C&CS has been fully re-oriented as a result of a hard look at the total post-attack possibilities and plausibilities, and is now under study by about a half-dozen different agencies.

DDR&E has scheduled a classified (secret) briefing to be held in Washington June 17 at which time it will describe the new C&C organization and objectives to an industry audience expected to number between 800 and 1,000 top-level executives. DDR&E is attempting to hold individual organization representation to two or three persons per company, at the president, vice-president, and director of marketing level.

In October, 1962, a DOD directive outlined the concept for the World-Wide Military Command and Control System that was to tie together the various service networks already built up with the new NMCS. Work on NMCS had been initiated earlier that year by DOD, with the Defense Communications Agency charged with the major development responsibility. DCA later brought in Mitre Corp. for assistance in technical planning and design. Technical support groups were also established within DDR&E.

• NMCS defined—According to Dr. Harold Brown, the NMCS consists of the facilities, equipment, procedures, and communications provided specifically for use by the national command authorities—which includes the President, Secretary of Defense, Joint Chiefs of Staff and their authorized successors and alternates—in providing strategic direction of the armed forces.

The national complex, in effect, provides for the strategic direction of operations conducted by the commanders of the U.S. specified and unified commands and connections with the subcommands, service headquarters, and their supporting agencies and systems. For FY '65, according to Dr. Brown, $34 million in R&D funds have been programmed for NMCS.

"In addition to the activity at the

IN 1774, one year before the outbreak of the Revolutionary War, Great Britain banned the exportation of arms to the colonies. It was not until the war was under way that the colonists took measures to provide a weapons arsenal. In Virginia, the legislature solved the problem by establishing their own forge on the Rappahannock River. Here, the first official American military pistols were manufactured and used throughout the colonies in the fight for independence. ▪ Today, solutions to the problems of defense are infinitely more complex and often directly related to the practical implementation of the computer sciences. ▪ At COMPUTER SCIENCES CORPORATION, experience and craftsmanship are basic capabilities applied to such areas as the design and development of a communication system for the nation's space program; problem-solution in atomic energy research; weapon systems studies; war gaming, and analysis of bombing systems for supersonic aircraft. ▪ A few of CSC's clients include IBM, RCA, Douglas Aircraft, Lockheed Missiles & Space Co., Jet Propulsion Laboratory, Litton Industries, Hughes Aircraft, Astrodata, and the U. S. Government. ▪ Write for a brochure describing CSC services.

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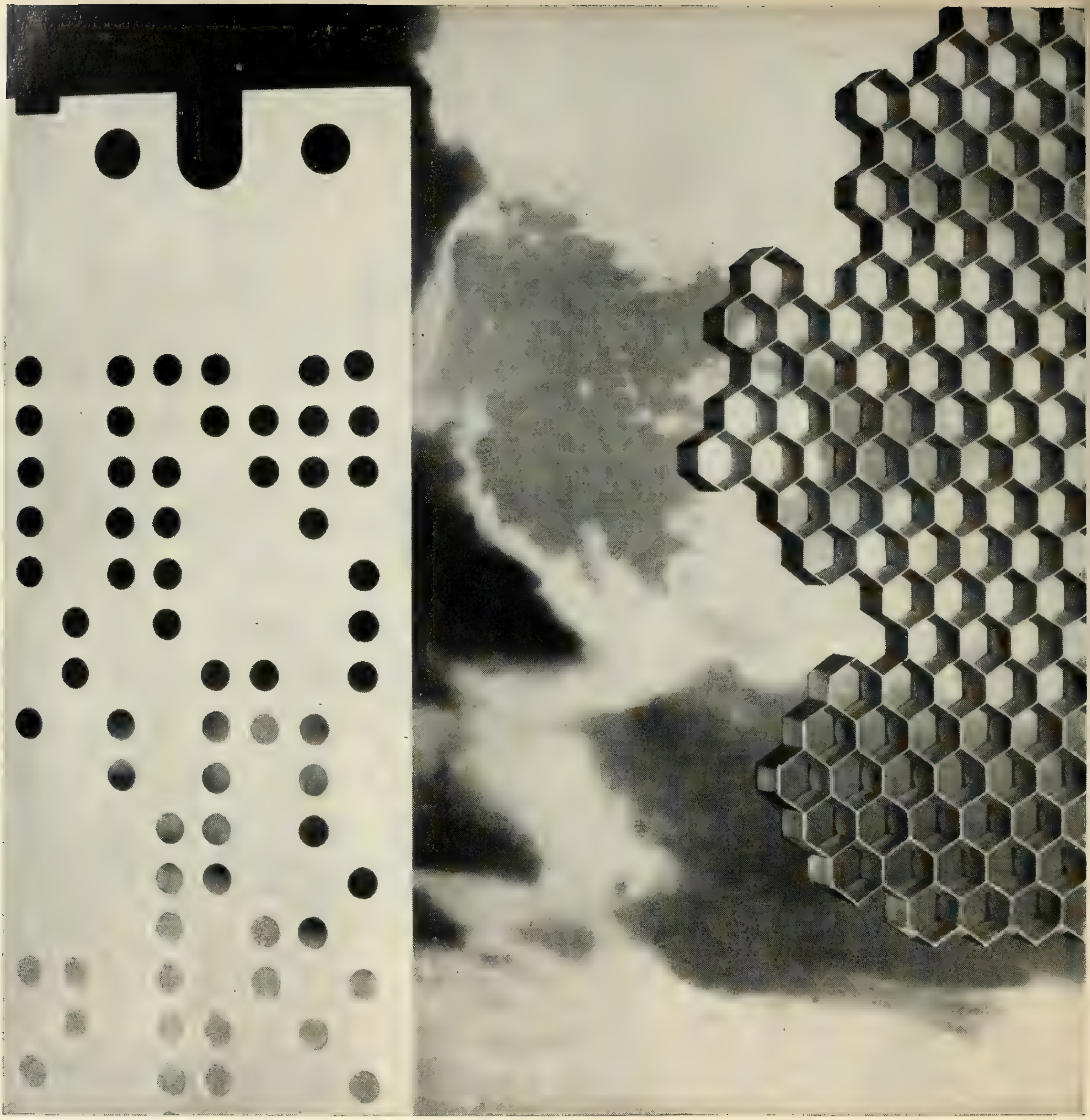

Program for a mission, pattern for a launcher

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A simple punched-card system provides a flexible method for programming the T-4 Electronics Countermeasures Simulator, developed by Reflectone Electronics, Inc., a UMC subsidiary. T-4 can duplicate virtually any RF condition which a B-52 ECM officer might encounter over enemy territory.

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NMCS level," one DDR&E officer reports, "each service has an active project to improve its own centers and its own commands."

NMCS as a physical entity is made up of four separate command posts, each of which is staffed and in operation. The four components include: the National Military Command Center (NMCC)—a "soft" facility—currently the heart of the operation, located on the first two floors of the Pentagon.

Work on NMCC, formerly the joint war room, has been under way for about 1½ years. There is also the alternative NMCC, a fully hardened site located outside Washington and staffed with a joint alternate command element; plus two other mobile alternate command posts airborne in KC-135 aircraft and afloat in USS Northampton-class vessels.

• **Feeder organizations**—Where NMCS is the decision-making spot providing direction for the unified/specified commands, the system is supported at the highest levels by a string of individual service command posts, such as the AF's 473L system, the Dept. of the Army C&C center, and the Navy's information center. In addition, two-way communications are also established between NMCS and DCA, State Dept., CIA, and the Defense Intelligence Agency (which filters foreign intelligence data before it gets to NMCS).

The unified/specified command systems to which NMCS is connected for direction of strategic attack includes the SAC 465L net, NORAD's 425L, STRICOM's 492L, CinC PAC, CinC LANT, the Army's EuCom and CinC South, and AF Alaskan Command.

Below the line of strategic commands comes the vast net of tactical commands and associated systems including the AF's 412L, the Navy and Marine Tactical Data Systems, the Army Tactical Operations Center (ARTOC) and its special Seventh Army system, and development programs such as the AF's Airborne Warning and Control System (AWACS), basically an airborne platform complete with sensors and commanders.

DDR&E's new structure for contributing to C&C development and refinement includes Dr. James M. Bridges, special assistant for C&C to Dr. Brown. The office provides a post from which the broad DDR&E total effort can be viewed. Bridges' deputy is AF Col. Paul R. Stoney. Dr. Robert C. Prim occupied this post last year.

In the Jan. 1 reshuffling, the DDR&E separate line post of technical director for NMCS, formerly held by Esterly Page, was dissolved as such, and the NMCS tech support duties now fall into the staff position held by Robert H. Scherer, as an assistant director under DDR&E Deputy Director Fred A. Payne for Strategic and Defensive Systems.

Scherer's office is responsible for both NMCS and C&C requirements for strategic systems. Under John L. McLucas, deputy director for Tactical Warfare Programs, an Office of Combat C&C was established headed by Col. Harold R. Johnson. Col. Johnson's office is within the Combat Systems office headed by assistant director Samuel O. Perry.

Further C&C support in communications and electronics among the DDR&E deputy director staffs comes from the Research and Technology staff headed by Chalmers W. Sherwin. Since Feb. 1, Sherwin's office of communications and electronics has been headed by Thomas Rogers. Rogers' deputy for communications is Willie L. Moore and for electronics, Ernest C. Wood.

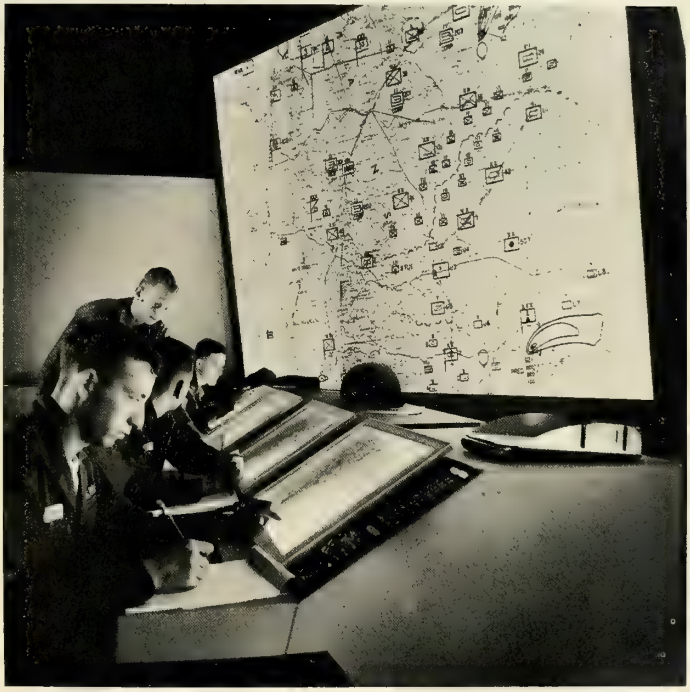
• **Common interests**—While there are individual efforts within the NMCS/Strategic, Tactical, and R&T support areas concerned with C&C, there is also a thread of developments which are of concern to all of these. Basically, the across-the-board needs in C&C are: improved communications reliability, survivability, and mobility; less complex displays and new techniques for presentation, including better man-machine interfaces and "absorption factor" schemes; more flexible on-line programming for computer systems; and fast data-processing schemes in compatible formats able to be controlled by the military commander.

There is expected to be a good market within the strategic C&C area for off-the-shelf catalog type items particularly for display and peripheral data-processing equipment, such as printers. Sizable research funds will be spent on development of a general-purpose on-line computer system capable of very high speeds.

Software programs will tend to be worked at more within the DOD than before, with DDR&E, ARPA, DCA, and the services playing leading roles. While Mitre and Systems Development Corp. still play important roles in developing programs and technical support, as the in-house competence grows, one official reports, "the magnitude of the nonprofit's contribution will diminish." Extensive use is planned for the new AF/Mitre Systems Design Lab (M/R, July 1, p. 36) at Hanscom Field.

The biggest payoffs for contractors in strategic C&C will come for those who advance improvements in survivable communications.

The magnitude of the military com-



MOBILE ELECTRONIC command posts such as this system developed by Aeronutronic Div., Philco Corp., will provide field army commanders easily assimilated displays of tactical situations. This data processing and display, together with other modern communication methods, will help control an area as large as 500,000 square miles.

munications problem comes to light when planners point out that about 90% of the current communications circuits used by the military are leased commercial circuits. "We are wed to AT&T," says one deputy director. Actually, with the possible exception of the percentages, most planners don't mind the idea.

Observers report that questions of being able to keep control of civilians manning communications nets in the event of war have resulted in effective training and indoctrination programs with the commercial carriers. Also, much has been done to develop new redundant circuit routing and panel switching to keep channels open.

● **Cutting commercial dependence**—The Defense Communications System managed by DCA has also grown in scope in the past two years and will probably alter the balance of DCA/common-carrier communications. The effort is to spread capability throughout the spectrum and in that manner achieve reliability, redundancy, and survivability. This includes current use of various tropo- and ionospheric-scatter systems, airborne relays, and cables, in addition to the more traditional microwave links.

Dr. Brown, in recent budget testimony, lent support to the military comsat program as a major objective in achieving the desired survival. However, many DDR&E observers believe there are also other ways to go. Particularly favored in some quarters is the Project West Ford approach.

The report dealing with the experiments to date reportedly portrayed the passive technique as highly attractive. There are some problems however, particularly involving ground site access and development of lightweight transportable stations. Whether or not an operational and useful West Ford system could be set up within two years, the time in which certain competitive systems might be available is still unanswered, according to DDR&E scientists. West Ford experiments will continue, say scientists, "but we have no other immediate plans."

● **'Last resort' systems**—Certain emergency communications systems also exist. Though most details are classified, an emergency rocket system is known to have been developed as a "last resort" SAC system. The launch vehicle lofts a communications package in a ballistic trajectory, spewing out data when all other means are gone. The system is strictly a special-purpose device.

While the AF has done studies on the potentialities of space-based C&C systems (sometimes referred to as SPACCS) for the 1970's as a natural outgrowth of airborne command post experience, high-level DDR&E officials show no inclination to move that type of effort out of the research and study phase until systems now at hand are being properly used.

Post-attack C&C is the biggest sleeper in the strategic realm. The concept is under intense scrutiny throughout the defense establishment and is understood to be getting a large share of study funding. The stakes are very high; a usable system could substantially alter the course of nuclear war.

While the U.S. policy of a flexible response is flexible to the extent that we can respond to a rifle with a rifle and not with a nuclear weapon, it is not yet flexible in terms of being fully able to look, shoot, and look into the later stages of a nuclear war.

What this means is that you cannot really fight a third and fourth strike type of battle, as opposed to a massive first strike, unless you are capable of seeing what you've done and what the enemy has done. (DDR&E planners express confidence that the current U.S. data-gathering capability would hold together at least through the early rounds of any nuclear exchange).

Furthermore, as a top DDR&E official puts it: "There is no sense in building up to go one way, unless you know the enemy can play." In other words, there is no real advantage in a post-attack C&C "gap," for if you still have assessment capability, and the enemy doesn't, it becomes very difficult to negotiate on the basis of your information alone or indeed to avoid having a second-strike launched at the U.S. by a nation which can't see what it did the first time around.

● **Complications immense**—The complications of putting such a system into being are immense. Advanced sensors have to be developed, some of those that are already developed have to be made to survive, communications must be insured, and the decision-making persons and processes have to be protected, as do certain numbers of weapons.

The area of tactical weapons C&C is one which is due for rapid expansion for three reasons. One, it is becoming clear that within the context of the current cold war situation, decisions about "incidents" or small-scale aggressive acts that were formerly made by field or area commanders may now have to be made at least in the U.S. if not at the White House.

This problem, officers say, at this point is still basically one of communications from areas of direct confrontation back into theater headquarters with increased amounts of data from which a higher command can make a decision. The objective is to improve systems so the U.S. can get this data back but still not overly complicate the field commander's job, which is more clear cut at the combat level. There is not yet an attempt being made to introduce very remote control of the actual tactical weapons application and control once doctrine is clear cut.

The second reason for expanded activity in this area involves the increasing dependence on U.S.-based tactical forces such as will be under STRICOM. While DDR&E officers say that the current European C&C networks (most of which are owned and operated by the U.S.) are well developed, such as the 412L and ARTOC systems, these will have to be augmented with very lightweight transportable equipments which can move with U.S.-based forces and control their weapons effectively.

● **Army stressing mobility**—The Army has been a leader in this area, and has assigned top priority to development of a very simple input device first, following with emphasis on compatible data processing and displays. The service is said to be thinking in terms of a 100-lb. area-type system.

As an example of the urgent need for these systems, one officer points to the Army's current efforts to test an air assault division and says: "We can't test this type of concept fully with our current day C&C systems."

The third reason is related to the policy of flexible response, whereby commanders on the tactical combat level will also have improved capability to control and apply their weapons.

In general, the weapons deployed in Europe today have been fitted into the existing C&C network. For example, the *Pershing* and *Sergeant* missiles have come under the Seventh Army ARTOC system. However, in the future, C&C requirements in the tactical area are expected to be very closely tied to the weapons systems themselves.

One of the first new programs to be set up this way is the Army's proposed *AADS-70* air defense system now under extended study by three contractors. Contractors have been ordered to provide considerable detail on C&C requirements together with basic weapons design. Should the system be produced, the prime contractor would then also have responsibility for providing the C&C, probably on a sub-contract basis.

Introduction of the *MMRBM* into European defense would almost certainly require new NATO C&C equipment as well as substantial improvement of U.S. equipment.

There is currently said to be a "very large problem" in standardization, particularly in data format and transmission equipment between U.S. C&C equipment and that developed by other NATO countries. The SHAPE Air Defense Technology Center at The Hague is coordinating efforts to improve compatibility. ■

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New Hardware Programs Should Aid Intelligence, Reconnaissance Functions

Office directs some of DOD's most highly classified studies, ranging from over-horizon radar to automatic data collection

A LOOK INTO the intelligence and reconnaissance (I&R) programs now being pursued within the office of the Director of Defense Research and Engineering to enhance the country's data-gathering capabilities shows that considerable attention is being paid to lasers, improved infrared detectors, ground-based over-the-horizon radars, airborne mapping and spaceborne radars (particularly side-looking radars for tactical aircraft), optical system design, and a wide range of new automated data collection and handling schemes.

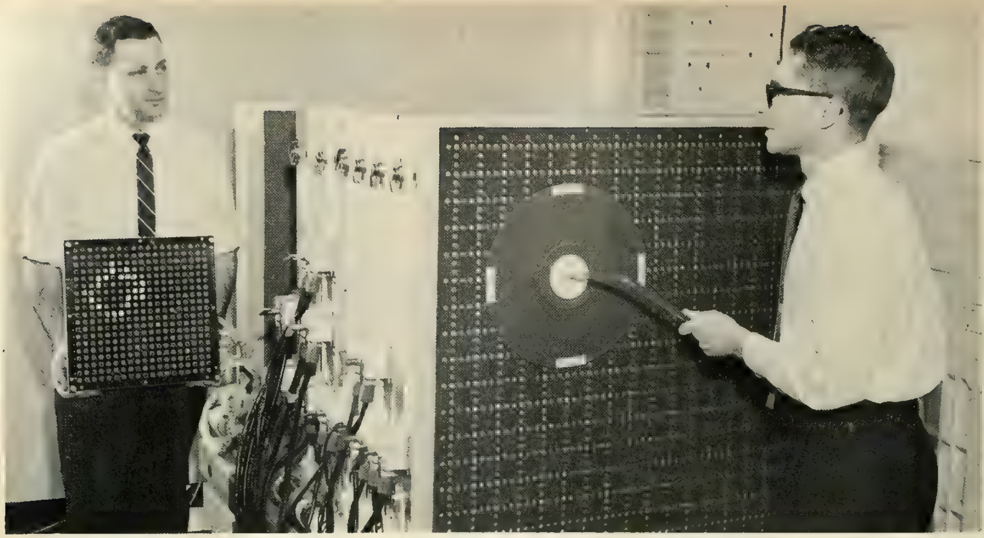
Control over developments in this area, one of the most highly classified within DDR&E, is vested in a small group of scientists headed by Bruno Augenstein, Dr. Harold Brown's special assistant for I&R. Augenstein is supported by a seven-man technical staff.

Although the upper echelon of the defense intelligence establishment is, both by the nature of the work and by design, a very tight little island, the relatively small size of the DDR&E I&R group does not obscure the fact that its programs are urgent—and often very expensive.

Within defense intelligence, the DDR&E I&R office is the one with the broad view and the access to all intelligence agencies, programs, and key personnel. All intelligence R&D at one time or another comes through Augenstein's office, which has the responsibility to review, approve, or modify it. Augenstein reports directly to Brown. While his office is primarily concerned with hardware R&D, not the actual collection of data, its spot on top of the total I&R effort means that it also initiates some conceptual work in addition to sponsoring some basic research.

MUSHROOMING DATA return from air- and spaceborne sensors has forced the intelligence community to pursue pattern recognition devices like the one above.

Because of the priorities now attached to I&R as a result of new weapons developments, the corresponding new difficulties in obtaining data, and the pitfalls involved unless virtually



ILLUMINATION of ground targets by laser beams holds promise of important gains in gathering of night or poor visibility intelligence data.

every approach is explored, I&R operates on a much higher cost-risk basis than other DOD offices, providing considerable incentive for advanced R&D.

"Our budget is fairly large," one scientist told MISSILES AND ROCKETS, "but while we are interested in economies, there is a very strong requirement to gather information, and if it takes more, we'll spend it."

- **C&C needs**—I&R interests span both sensor and system development and in many cases touch on related areas of development within DOD, particularly command and control.

For example, there is a critical need in C&C for new "software" programs to improve the military commander's ability to communicate rapidly and meaningfully with his supporting computers (M/R, Dec. 3, 1962, p. 16). The interest here is in "non-numerical" capabilities as opposed to present capabilities in numerical data processing.

One area involves development of computer systems which could respond to an English-language program; possibly being fed punched-card questions written in English which are read with optical readers and analyzed within the computer to yield a specific type of data. I&R scientists say they are now at the beginning of some real success in this field. Scientists at the Advanced Research Projects Agency, under Dr. J. C. R. Licklider, are making the major effort in these areas.

I&R scientists also have a substantial effort in the related field of automatic language translation, though admittedly at the moment the machine still cannot compete for the major role in this task. Experts point out that a great deal of useful intelligence information can be very simply obtained from foreign literature, though not in the quantity nor with the easy access of U.S. data.

- **New logic**—Also in the data-processing area scientists are pushing hard for development of new recognition logic circuitry in sensors which could be used in a reconnaissance vehicle to cut down on the proliferation of data, much of it redundant, which is being gathered and transmitted. I&R scientists admit they have not been able to do this yet and feel they will probably have more luck initially with an interim approach wherein all data is collected and the recognition logic is built into the ground equipment. Some of this equipment is already in service.

The type of logic sought is not merely adaptive-type circuitry in which only data which falls within a specified range is transmitted. What is needed, the scientists say, is a means to compare new signals received by an airborne or spaceborne sensor with a large stored data base. Also, they note, "the more precisely defined you want the signal, the more trouble you have with spurious electromagnetic radiations." To counter these problems, I&R works closely with the DOD's Electromagnetic Compatibility Analysis Center (ECAC) at Annapolis, Md. (M/R, Mar. 9, p. 17).

ECAC's spectrum signature files and ground environment studies are aiding the intelligence net to avoid picking up what we already know. Expansion of ECAC's data base to include NATO countries, combined with knowledge of Communist-bloc radiations, is expected to significantly improve ferret-type ground and spaceborne systems in the future.

- **Post attack**—Certain of I&R's programs also impinge heavily upon the U.S. interest in post-attack command and control (see page 79).

Should this program, which is now being worked on by several agencies, ever be spelled out and emerge as a going project, its hardware requirements would be vast. A wide range of information would be needed and there would be a lingering degree of uncertainty as to what would work after an attack.

Post-attack C&C, in essence, involves a running inventory of damage, status of forces, and a whole list of other inputs which could even include national personality factors. The object is to know as completely as possible the effects of the first stage of the U.S. "controlled response," so that we can either negotiate before the second stage or more effectively apply our second stage.

In the realm of sensor development to support PACCS, scientists are interested in nuclear detection systems which will give an indication of our attack's effectiveness. Such a system would involve nuclear-burst sensors and associated timing devices, timed to within seconds of the computed impact time for a specific vehicle launched against a specific target. Keeping the sensor response time to within seconds would rule out false indications due to a missed target or a nearby AICBM burst.

Electromagnetic sensing devices, both ground-based and space-based, would also be employed to quickly gather data on what enemy equipment was still operating.

In addition, there is much interest in optical and radar damage survey. The high-performance RS-70 was originally slated for this role, making a fly-over either immediately after a first attack or in the closing stages to ascertain what damage was done and to hit targets of opportunity en route. While sensor packages are available to configure U-2's or B-52's for this, it is highly unlikely that they would be useful in this mission due to vulnerability

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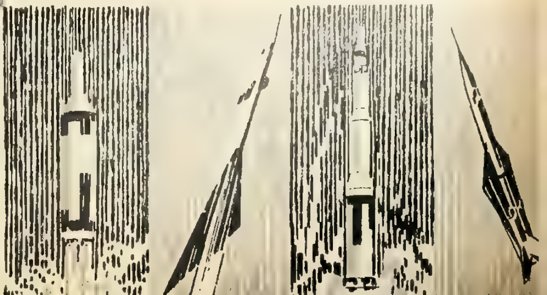

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and speed considerations. On the other hand, one top scientist told M/R that after a first attack, "we could possibly penetrate the Soviet air defenses with a 707."

● **Who hits what**—The speed with which this damage is assessed is vital to solving one of the biggest headaches of post-attack strategy, namely the recommitting of second-strike forces from one command to another. In brief, it is highly likely that some targets missed by one command may be more important than those missed by another; therefore the need for data to decide on which targets must be hit in a second strike and with whose weapons.

The use of satellites to solve this problem is being considered. Here too, there are trade-offs. For example, unmanned satellites using TV readout involve bandwidth conflicts between the need for high-resolution photographs and rapid transmission. Using a manned vehicle for rapid coverage and direct voice communications is an alternative.

Decisions affecting the overall integration of manned spaceflight into the intelligence net are still to be made. "Hopefully," says one scientist, "man will be able to point optical systems, take film, process it in orbit, and report his interpretations. He also could adjust and repair equipment. However, just having him there adds to the cost and complication of the system. In short, we need to have experiments with man in orbit before we can make a decision."

● **Laser angles**—The I&R efforts into laser usage may well re-open an optical surveillance technology which is already pressing against the performance stops. Whereas current optical reconnaissance systems design is based on the properties of incoherent light, DDR&E scientists are sponsoring investigations of how improved systems can be achieved using coherent laser light.

For example, scientists told M/R that color aberrations which complicate standard photo-reconnaissance can be eliminated with laser techniques. Also, the use of laser illumination may turn out to be the answer to a major problem the services now have in night photo-reconnaissance. The illumination could be done either in the visual or IR range. Scientists report it is not yet evident which is better. There is a feeling that this technique could be applied from satellite altitudes. It is almost certain that these experiments will be tried during the *Manned Orbiting Laboratory* (*MOL*) program, and it is also likely that "primitive tests" may come during the manned *Gemini* series.

I&R is also said to be sponsoring a substantial amount of applied research toward high-power, smaller, simpler, and lighter-weight laser systems.

● **Optics and photography**—Camera lens system design, largely through new impetus supplied by I&R, is now also evolving from the traditional straightforward and laborious light path tracing into a programmed, automated operation which yields optimum lens design. Actually, I&R scientists report that there has been so much progress in design of high-quality optics that systems now are very close to theoretical operating limits. Further progress requires improvements in measurement instrumentation and increased basic understanding of physical properties of materials.

In a related field, I&R is also interested in basic research concerning the relatively old subject of what constitutes resolution in a photograph. Questions concerning the processes of photo interpretation revolving around resolution are still treated in a subjective way, say the scientists, and the research is aimed at finding out if this process can be quantified and made more objective.

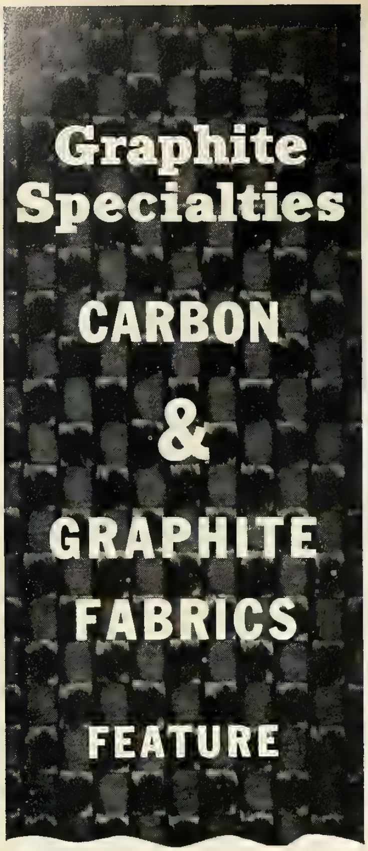
There is also, according to I&R scientists, "a tremendous amount of learning involved in IR photo interpretation." Though IR started as basically a photographic technique, some observers feel it may be better to use IR to pick up things which do not have any photographic analog.

For example, scientists say that "camouflage, if well done, is very difficult to detect with a photograph. However, with a good IR set which could detect small temperature differences, we could tell the difference. That kind of interpretation is what we have high hopes for. There is lots of work going on," they report. "The types of detecting cells for this work, however, might require refrigeration down to liquid nitrogen temperatures."

As another example, scientists told M/R that "underground installations can be designed to be indistinguishable to the naked eye or to photos; however, an IR sensor could pick it up if, say, the concrete liner was at a different temperature, even under a soil layer, or if something in the installation had to be kept at a certain temperature."

There is also application in detection of submarines where 0.002-deg. difference in the water temperature of a submarine wake could be detected, though thermal layers in the water above the sub in some cases could keep the wake down.

I&R is also known to be sponsoring some research into so-called "scar" surface wave pattern detection from high-altitude aircraft, an optical technique which grew out of IR technology. Apparently, wave patterns of objects just below the surface appear markedly different from high altitudes, enhancing



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the ability to pick out submarines with optical techniques.

- **MIDAS and beyond**—Much of the impetus for the wide range of IR work now being used in several I&R efforts has come from the *MIDAS* (*Missile Detection and Alarm System*). There is some irony here, however, since informed sources generally believe that *MIDAS* will give way as an operational means to provide improved ballistic missile launch warning to a lower-cost, ground-based, over-the-horizon radar system.

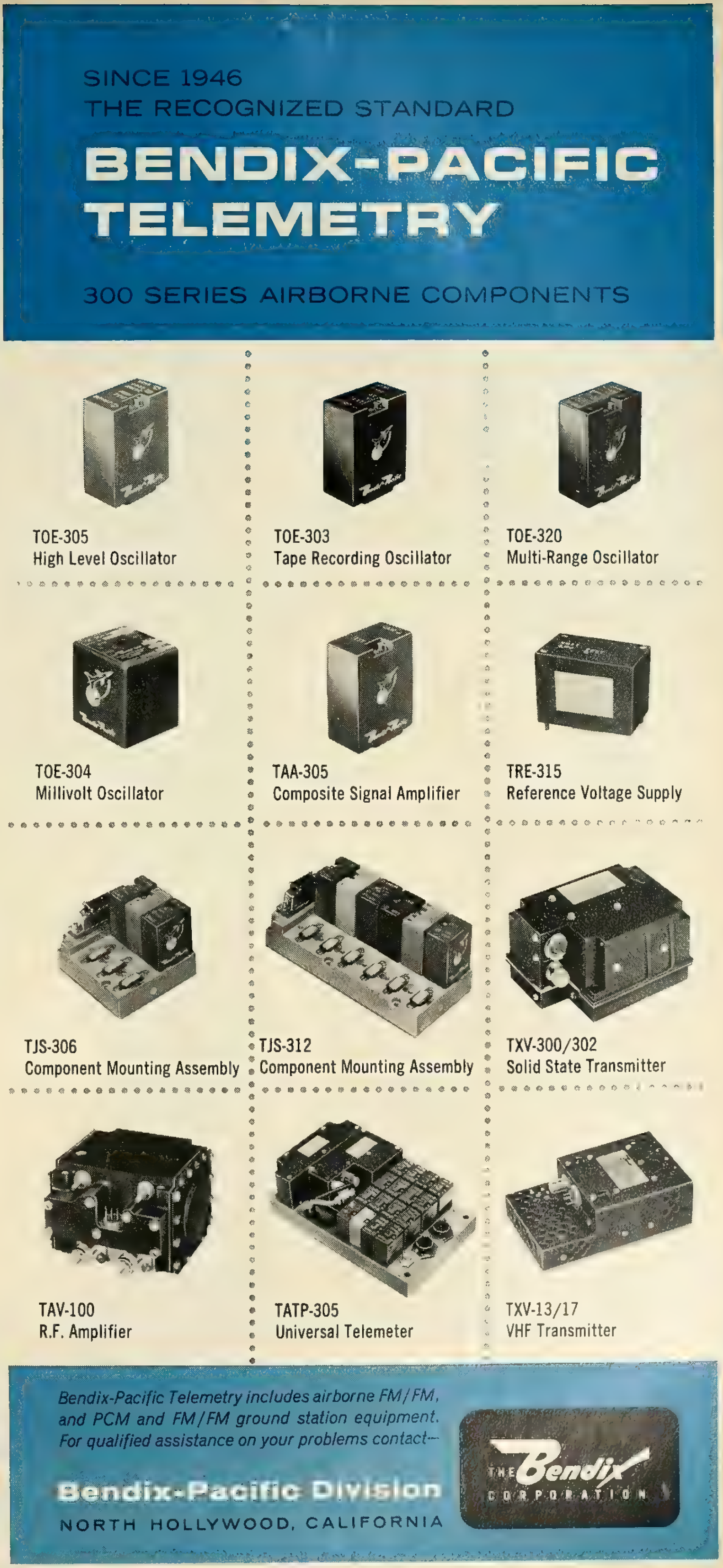
Though *MIDAS* has scored some successes (M/R, Feb. 3, p. 19) and has been improved through reduced cryogenics requirements in its sensor elements (M/R, Feb. 17, p. 9) one of the major reasons the program is now under review within DOD is reportedly "because other intelligence-gathering systems, such as advanced radar, are beginning to show promise." Development of over-the-horizon radars, both of the forward-scatter and back-scatter types, has progressed into field testing and in recent weeks has been the subject of favorable comment by top DOD and AF officers (M/R, Feb. 24, p. 44).

With the exception of *MIDAS*, which has been talked about relatively openly, the remainder of the U.S. intelligence satellite operations, particularly the now re-designated *SAMOS* program, has been given both the highest national priority and classification. It has been previously reported (M/R, July 29, p. 55) that photographs taken by these satellites were equivalent in quality to those taken via high-altitude aircraft reconnaissance.

Though little is known about the advanced system said to be under development, data accumulated earlier in the *SAMOS* program indicates that a 6-9 satellite system is used, with TV scanning of on-board processed film providing quick-look data and capsule recovery of film providing detailed analysis. An electronic ferret-type version of the satellite is also thought to be in operation.

Whereas use of satellites for electronic eavesdropping is known to be of considerable importance now, especially for picking up line-of-sight-type emissions, it is expected that in the future increased use for portions of this mission will be made of very large steerable dish or array radars, which reportedly can collect far more of certain types of data than can a satellite.

Among the more esoteric programs in which I&R is now working are efforts to develop various chemical sensors, or air-sampling devices, sensitive enough to detect the presence of persons not visible through foliage or tree cover. There are reports that similar experiments are being run using IR for this same purpose. ■



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Administration & Management Stresses Better Information Distribution

New Plans & Policy directorate established; Engineering Management, Technical Information offices charged with program execution and technical information flow

THREE EXTREMELY IMPORTANT areas of concern to the military research and development community—Plans and Policy, Engineering Management and Technical Information—are centralized under the Deputy Director for Administration and Management, Lt. Gen. William J. Ely, USA.

Still too new to have made its presence felt, the Assistant Directorate for Plans and Policy has been established to pull together the threads of R&D policy, transforming them in the process into a coherent whole. Paul J. Sturm, formerly of the planning and marketing department of Motorola, joined DDR&E on March 1 to head the office.

This is the first formal planning group within DDR&E. Bits and pieces of this function had been carried out by various parts of DDR&E, but Sturm's group represents the first major effort to give real stature to policy planning.

Not involved in the planning of hardware, Sturm will act as the principal point of contact with the Joint Chiefs of Staff in terms of future military requirements. Specifically, he will be involved in planning, coordination and documentation of the Research and Development annex of the Joint Development Objectives Plan (JDOP)—a major Joint Chiefs of Staff (JCS) planning document.

Plans and Policy's specific areas of interest will evolve as the organization takes root and grows. However, in addition to working with the JCS, the office will also be responsible for:

—Monitoring of the advance planning briefings for industry;

—Overall resource information on the military R&D program;

—Resolution of differing approaches in defining requirements (the Army's Qualitative Materiel Requirement [QMR] vs. the Air Forces Specific Operating Requirement [SOR];

LT. GEN. WILLIAM J. ELY heads Administration and Management

—Serving as primary point of contact for the Federal Council of Science and Technology, including the preparation of DOD R&D position papers:

—Continued-action items resulting from fallout from the Bell Report; and

—Specific assignments for the Director of Defense Research and Engineering.

• **Engineering management**—Whereas Sturm is responsible for the advance planning of the R&D program, James W. Roach, Assistant Director for Engineering Management, is in charge of overall execution of the program. His job is to improve the management process of military research and development.

The recent project definition directive, for example, was a product of Roach's office. This document, issued earlier this month (M/R, Mar. 9, p. 14), was pilot-tested on *Titan III*, *MMRBM*, the military Comsat and *Lance*, and is now the rationale for the approval or disapproval of a Technical Development Plan.

A potpourri of some 95 tasks in nine different areas, Roach's responsibilities span the gamut of R&D management. The nine general areas are: Project and Program Initiation, Project and Program Management Procedures, Research and Engineering, Communications and Management, R&D Economics and Technological Factors, R&D Contracting Procedures, Reliability, Maintainability and Design Processes, and procedures and Management Services.

With such a wide range of interest—and with only seven professionals besides himself in the office—Roach has had to select eight to ten tasks a year on which to work—allowing the others to stretch out. Some of his work, however, is expected to be absorbed into the Plans and Policy office.

One of the tasks that Roach is working on is a review of the mechanisms within the Dept. of Defense for definition of military requirements. The purpose of the study is not to attempt to define military requirements but to define how the different DOD organizations define their requirements.

Of particular interest are the intraservice mechanisms—as well as the interservice methods; for example, how and in what form and detail requirements are passed from the services to the JCS, from the services to DDR&E and from the JCS to DDR&E.

A subcommittee of the Defense Industrial Advisory Council is also examining this problem in order to add both objectivity and another viewpoint. The purpose is to ensure that Defense organizations are using the best of

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In another representative area, Engineering Management is examining the unity and consistency of PERT/Cost reporting through an interagency group. The feeling is, however, that the only way to guarantee standardization of reporting is to standardize the information requirements and reporting systems at DOD level.

- **Information stressed**—The third area and the one getting the most emphasis in administration and management these days is the pepped-up office of the Director of Technical Information. DDR&E is so concerned about problems in disseminating technical information that according to Gen. Ely, "it occupies about two-thirds of my time."

New director of information is Walter Carlson, who came to DOD after more than 20 years in industry.

Under Carlson's direction, what promises to be one of the most comprehensive studies in this field is getting under way. DOD has contracted with the Auerbach Corp. of Philadelphia to make an intensive survey of the technical community to see how information is acquired, what information is used and how it affects the technical man's work.

Interviewers are now conducting pilot studies to firm up the types of questions they will ask. Random samples of perhaps 1,500 to 2,000 professionals of the approximately 30-40,000 working in DOD government laboratories in research and development will be interviewed in depth.

The survey will be unusual. For instance, besides asking "what publications do you read," the interviewer will ask to see a copy of it, then continue to press to ascertain whether the person does, indeed, regularly read it. He will go further to see whether the scientist gets useful information by phone, or through conversations with his colleagues, or by other means. Says Carlson, "We're not assuming that libraries or technical journals exist. We want them to tell us."

More important, the interviewers will seek to discover how the information was used—what concrete effect it had upon the man's work. Mr. John Sayer, project chief at Auerbach, explains it as a systems concept in which man is part of an information system, rather than a study of information sources.

The scientists and engineers, who will remain anonymous in the study, will also be asked what information sources they knew of, to see if there are any available that they could have used. They also will be asked to suggest what presently non-existent sources might be created.

Carlson estimates that DOD spends $60 million on information materials in-house, and that DOD contractors efforts probably bring this figure to $200-$300 million a year in support of the research, development and evaluation effort alone. Engineering data would take this well over $1 billion, he estimated. "And with all this, we still don't know what information is used."

- **Questionnaire available**—Carlson disclosed that DOD will make the questionnaire available when it is ready in a few weeks from now.

He indicated his hopes that industrial organizations will also wish to conduct the survey, so that some really definitive results can be gleaned. Some training of the interviewers will be necessary, however, since the survey is partially open-ended.

At least 150 surveys of information sources have been made, he said, but none asked the basic question of "what did you do?" Too often, interviewees give the answers which tend to make them look good.

In this case, the scientist or engineer will be asked to describe the most recent project or piece of work he did, and relate what information he used, where he got it and how it was used. The "most recent one" is chosen, Sayer explained, since if the interviewee is allowed to choose an incident, he tends to pick one which stands out in his mind only because it was unusual, Sayer explained.

Carlson said that after all this information is gathered—by the end of the year, it is hoped—and if trends emerge, his office will then look at the possibilities of new packaging of information materials to enhance their use.

- **Other programs**—Carlson's influence has already been felt in DOD. Since his arrival on the scene on Feb. 1, 1963, a number of things have been accomplished.

One of the first priority items was to ensure that the military services were carrying out their responsibilities in the information field. The Army had already taken up the problem, and was ready with a comprehensive plan for its own use, Carlson said. Thus, the Army went ahead last February with improved methods.

The Air Force published its plan last month, according to the director, and will go ahead soon. The Navy has been delayed somewhat by its own reorganization, but DDR&E is working to bring it up to the level of the others.

Carlson meets every week with representatives from the three services and the Office of the Secretary to review the program. Because of top-level concern, he said, the program is getting fairly high priorities.

• **ASTIA out**—The old Armed Services Technical Information Agency was given a new name and home, and completely revamped. Carlson said that he felt that there should be a decentralized system, but there was a need for a Defense Documentation Center.

Thus ASTIA was shifted from the Air Force to DOD level, and eventually became relocated with the Defense Supply Agency. The rule that restricted data had to be sent back through the originator for declassification was removed, speeding the process up considerably. In addition, an order was placed for a Univac 1107 and a 500,000,000-digit random-access memory.

• **Next task**—The next priority job, Carlson said, is to get the information centers pinned down. These include such groups as the Defense Metals Information Center at Battelle Memorial Institute, the Plastics Technical Evaluation group at the Piccatinny Arsenal, and the Oceanographic Data Center.

DOD has money in about 40 such centers, the director said. Some are in-house and some operate by contract.

A DOD instruction has been drafted and eventually the centers will have firm assignments to whatever service best fits them, "giving them an administrative home rather than requiring the services to pass the hat," Carlson said.

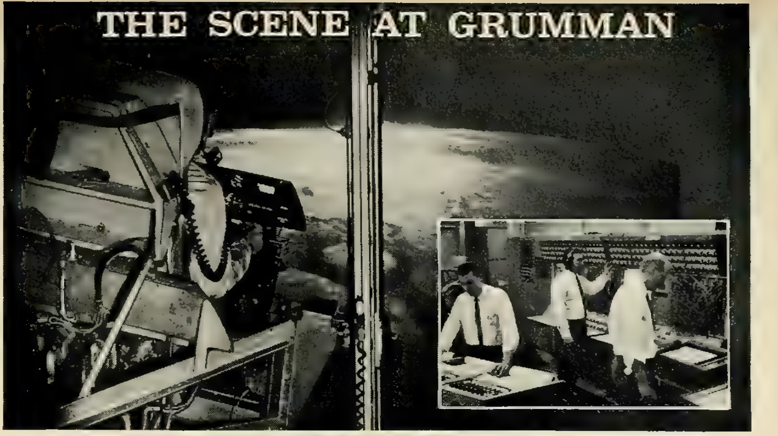
Still further in the future will be a study of the technical library system throughout DOD. The director said he did not know whether anything was wrong with these libraries, but that they would be scrutinized in terms of how they might be improved if necessary.

He also added that DOD supports a research and development effort in the information sciences worth a total of about $8 million a year. His office eventually will look at that to see if the job is being done correctly.

• **Office small**—Carlson has only two other professionals to aid him in his task. He said that the office is small by intention; the jobs are awarded to the services themselves, and the Technical Information office is limited to setting policy and supervising, coordinating and reviewing.

There has been some criticism of this division of the information process, but in Carlson's words, "we just have too much to do now."

The technical information office is coordinated with the Federal Council of Science & Technology through a subcommittee on scientific and technical information. A subcommittee of this group—including representatives from DOD, NASA, the Atomic Energy Commission, and the Department of Commerce—resolves operating questions. ■



...Lunar Landing Simulator

The "first" Lunar Landing of the LEM (Lunar Excursion Module) has been made . . . in Grumman's lunar landing simulator.

Controlled by analog computers, the simulator is utilized for control system parameter studies and for evaluation of lunar landing techniques. Basically, the simulator comprises a two-degree-of-freedom motion seat and a four-degree-of-freedom visual display.

Shown above at the analog computers are Engineer Robert Herdman (joined Grumman Jan. '63), Morton Hausner, Analog Computer Analyst (joined Grumman '61) and Fred Wood, Systems Simulation Engineer (joined Grumman '54), monitoring simulation of Gray Smith, Advanced Systems Engineer (joined Grumman '50) performing lunar landing.

One of the pleasures of working at Grumman is the advanced facilities that enable our engineers to subject men, theories, and designs immediately to comprehensive experimental verification . . . widening their technical horizons while they work!

Space Systems Engineers whose interests and training are aligned with the broad scope and operation of systems engineering are invited to pursue further the many interesting and challenging job opportunities open on the LEM Project. Applicants should possess a BS degree in Engineering and have at least two years of experience. The following specific job descriptions are typical of the type of openings now available.

Systems Analysis Engineers — to determine specific systems design criteria and performance requirements from basic mission objectives and theoretical considerations and to define and follow through on studies required to achieve compatibility among the major space vehicle functions of guidance and control, communications, life support, etc. Other assignments include system optimization studies with respect to overall vehicle performance, reliability, weight, etc.; determination of optimum allocation of error budgets among major subsystems; development of mathematical models of spacecraft subsystems and verification of adequacy of these models against dynamic operation of actual equipment; determination of systems oriented objectives for simulation programs and interpretation of simulation results; and the analysis of laboratory and field test results of vehicle systems and the determination of effects upon overall system performance. Applicants should possess a good working knowledge of the theory and operation of one or more of the following equipment areas: navigation and guidance, airborne radar, space propulsion, airborne stability and control, and airborne digital computers.

Systems Integration Engineers — to perform functional integration of advanced aerospace electronic, mechanical, and fluid equipments for lunar landing vehicles. Applicants should possess a working knowledge of spacecraft equipments such as guidance and control (analog/digital), communications, environmental control, and propulsion. Task assignments encompass functional integration of space vehicle equipments with emphasis on applying mission requirements to equipment functions. An additional requirement includes a capability to effectively communicate with specialists in various aerospace fields.

Interface Control Engineers — to effectively coordinate technical data with specialists in various aerospace fields and at all levels of management. Task assignments include definition, coordination and negotiation of interfaces between company and associate contractor equipments. Applicants must be willing to travel extensively.

Checkout Systems Engineers — to develop overall checkout systems philosophy, requirements, and criteria for space vehicle equipments. Task assignments encompass the establishment of ground rules for the selection of inflight and ground checkout parameters and of applying these ground rules to space and ground test vehicle equipments. Assignments include mathematical analysis of checkout effectiveness, determination of tolerance levels at various checkout stations, and establishment and monitoring of detailed equipment checkout functions.

Mission Analysis Engineers — to analyze lunar flight missions as well as LEM vehicle development missions for the purpose of determining mission related design requirements on flight hardware and on support equipment. Assignments include performing contingency studies, operational feasibility studies, abort studies and any other studies required to assess the impact of the mission on equipment design as well as the effect of equipment limitations on the mission profile. Close working liaison with the equipment engineers as well as with flight test and operations personnel is required.

To arrange an immediate
interview, SEND RESUME
to Mr. P. M. Van Putten,
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Employment, Dept. GR-86.

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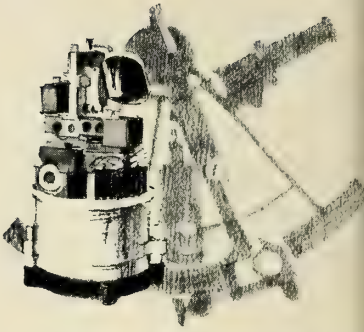
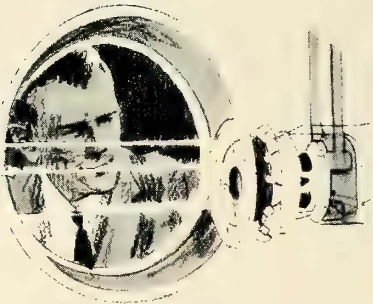
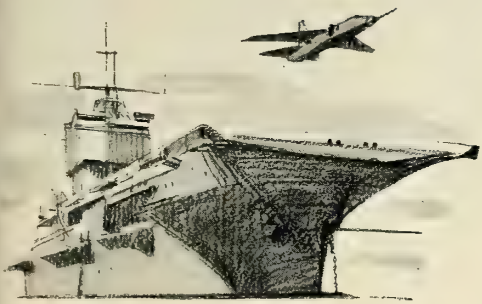


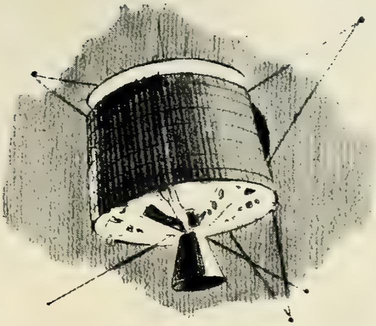
Hughes is: Surveyor, star tracker,



ion space engines, microelectronics,

missile systems, and more . . .





Enterprise ‘eyes’, Syncom satellites,

command and control, laser-rangers,

Hughes is a company of nearly 30,000 – including over 7,000 engineers and scientists – applying their skill and imagination in space, in national defense, and for commercial purposes.

The examples: **Surveyor** – Will soft land a scientific package on the Moon. Will gather and relay information about the Moon to earth, paving the way for our astronauts. **Star Tracker** guidance device for the Surveyor. One of Hughes’ many infrared advances. **Enterprise ‘eyes’** – Large, flat radars that show aircraft in 3-D. **Syncom** – the first communications satellite “parked” over the earth. The first to operate ’round the clock to break all records. **Ion engines** promise to be the most efficient way to propel space ships to distant planets. **Microelectronics** – saving power, space and weight by making the electron work in new ways. **Command and Control Systems** – using computers to give battle commanders up to the second information for decision-making. **Laser-rangers** – applying the laser in measuring distances. **Missile systems** – In service: thousands of Falcon missiles. Soon, Phoenix missiles and guidance electronics for the Navy’s new F-111B jets. **And more!** There are more than 553 projects, products and services at Hughes.

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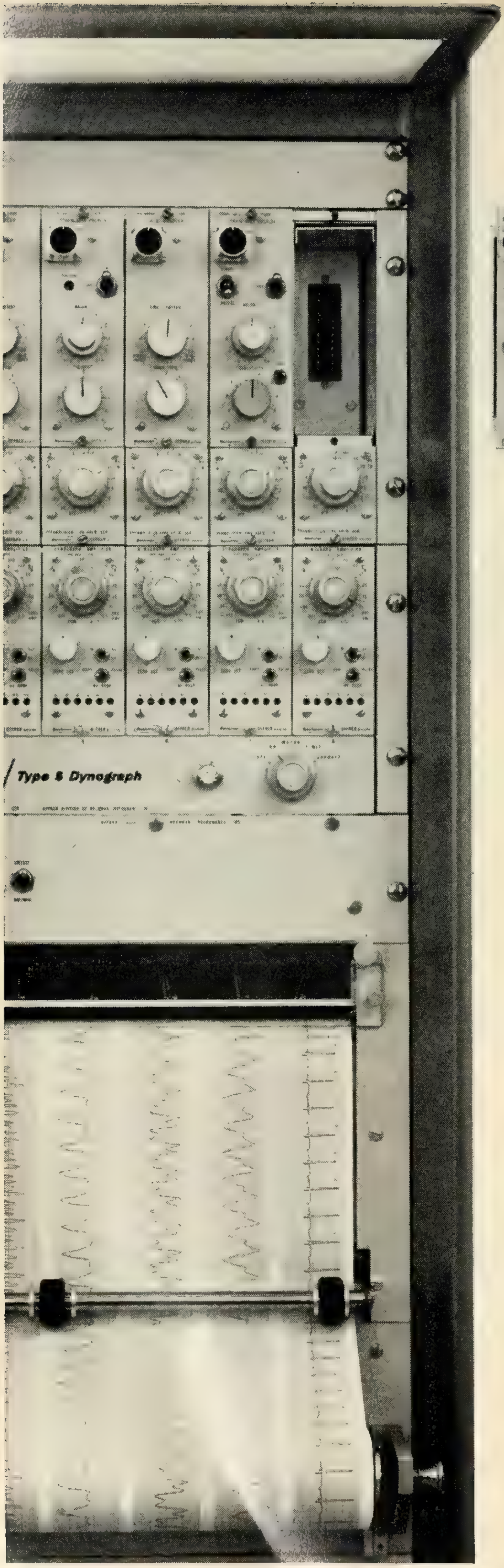

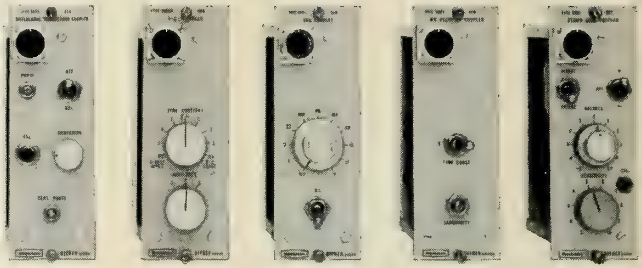

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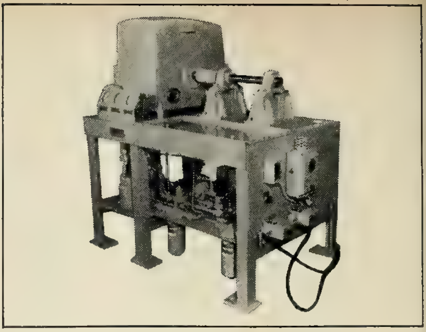
GI's track vehicle with experimental radar unit.

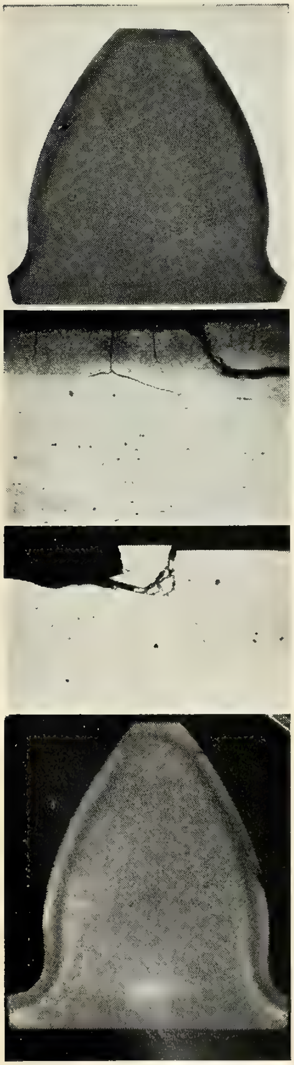
DDR&E part III

RESEARCH AND TECHNOLOGY

From Caterpillar research...comes a new testing device to study the twin problems of metal surface fatigue and lubrication failure

Today—as the relentless demand for ever-increasing horsepower from smaller and smaller components continues—research in metal fatigue and lubrication failure has accelerated tremendously.





Cross-sections reveal three distinct modes of failure in surface fatigue. Top photo shows a case crushed gear tooth. Second, a case crushed roller. Third, sub-surface pitting and fourth, a surface pitting crack.

Lubrication

Early work with lubricants involved application of the classic Reynolds Hydrodynamic Theory. Later the concept of thin film —or elasto-hydrodynamic lubrication support of machine elements—allowed a more basic understanding of why lubricants work as well as they do. But the question of the technique to be used in evaluating the load carrying capacity of the many lubricants and additives remained an unresolved one.

Lubrication failure data which can be correlated with actual parts has been virtually unobtainable because variables which affect lubricants could not be measured in a working gear mechanism.

Surface Durability and Wear

And in the past the only means of obtaining reliable data on surface fatigue, as well as lubricant capacity, has been Destruction Testing of full-scale components—a time-consuming, costly, frequently inconclusive procedure.

The theories for failures of material are equally as numerous and complex as those for the failure of the lubricants. The lack of knowledge about the many load, speed, and temperature variables has led to serious misunderstandings and misapplication of principles of design and heat treatment.

Our research people have long sought a better understanding of material and lubricant capacity. Their specific objective: an accurate means of predicting surface durability and scoring resistance in vital vehicle parts and components.

Controlled Environment Testing

Drawing heavily on earlier research, Caterpillar engineers devised the Geared Roller Test Machine. It reproduces—in a controlled environment—any load or sliding velocity generated in the transient conditions of actual machine operation.

Since the device can duplicate the entire known and anticipated range of gear loads and speeds, we can use it to predict how new gear, cam and bearing designs will function before such a system is manufactured.

And, too, we can now predict what type of lubricant will function effectively in a given gear machine and the conditions under which the lubrication will fail. The machine is also being used to evaluate new oils—and contributing to the development of lubricant refinements and additives.

Saved: Precious Time and Money

In addition to providing needed data and understanding on metal and lubricant behavior, the test machine has already played an important role in reducing hardware development time at Caterpillar.

To speed the gathering of test data, Caterpillar is now offering Geared Roller Test Machines to other manufacturing firms, research organizations, universities, and government agencies. The device is already being used by an electronic computer manufacturer, an aircraft producer, oil companies, and bearing manufacturers, as well as gear manufacturers, in the evaluation and development of their own products—to the final benefit of industry.

Caterpillar's accumulated experience in basic metallurgical and lubrication research is also available to help purchasers of the machine set up their programs and evaluate their test data.

For further information, contact Defense Products Department, Caterpillar Tractor Co., Peoria, Illinois.

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Change in RDT&E Budget Structure Could Trigger Far-Reaching Results

'Categories' approach to military R&D provides constant monitoring so that only most useful concepts become weapons systems

A VIRTUALLY UNHERALDED change in the structuring of the Research, Development, Test and Evaluation budget promises to have as profound an effect on the development of military technology as did the Program Package concept on the overall Defense force structure.

With the presentation of the Fiscal Year 1964 budget, the RDT&E program was broken down into six distinct categories: Research, Exploratory Development, Advanced Development, Engineering Development, Operational Systems Development and Management and Support. This represented the first budgetary application of this approach, although the sagacious observer could have predicted the application of some such system by a careful reading of *Economics of Defense in the Nuclear Age,* written in 1960 by Charles Hitch, then a Rand Corp. economist, now Dept. of Defense Comptroller.

Basically, the categories of research and development are designed first to make the military R&D program "visible" and then to provide a means of constantly evaluating the military worth, cost and technical promise of various technical approaches to the solution of military requirements.

With the proliferation of technology, Defense officials realize that the Department cannot afford to support all the potentially good ideas that come along. Therefore, they feel, the "seed corn" of militarily useful research ideas must be identified, nurtured and protected until it comes to fruition or is winnowed out in the fields of exploratory or advanced development.

• **The visibility problem**—Under the old procedure—and incidentally the same procedure still used to present the RDT&E budget plan to Congress—the R&D budget is broken into four accounts: Army, Navy, Air Force and Defense Agencies. Within each of these the budget plan is itemized as:

Military Sciences;
Aircraft and Related Equipment;
Missiles and Related Equipment;
Military Astronautics and Related Equipment;
Ships and Small Craft and Related Equipment;
Ordnance, Combat Vehicles and Related Equipment;
Other Equipment; and
Programwide Management and Support.

A primary difficulty in this type of presentation is the determination—even within the Military Sciences category—of the relative amount of money being spent on Research, Applied Research or just plain applications engineering for the development of weapons systems. Another difficulty is that each of these line items contains, in varying degrees, support of in-house installations and non-profit organizations. Finally, it is difficult to relate to one another comparable development efforts within the services.

The worst fault in this system, however, is that it does not inspire an orderly and selective flow of technology to provide the basis for a considered decision to develop a weapons system. Defense officials feel that the result too often has been a premature decision to develop a weapons system, necessitating the expenditure of vast additional sums of money to develop technology which should have been available in the beginning. Since budgets are limited, this has meant that research and exploratory development funds were reprogrammed to cover these overruns—thus depriving future military systems of technology which should have been under development.

To achieve visibility within the RDT&E program, the budget plan has been broken down into some 325 program elements, which in turn are composed of some 1,300-1,400 projects. Finally, each project has associated with it varying numbers of tasks—a development task being the lowest identifiable unit of work. There were some 20,000 tasks in the FY '64 budget program. (M/R, March 25, 1963, pp. 41–49).

As illustrated on the chart (following pages), the program elements are major groupings under each of the categories. They range from specific weapons systems such as *Minuteman* and *Nike-X* to broad research areas such as physical sciences. Twenty-two program elements in the engineering and operational development categories accounted for nearly 50% of the RDT&E budget.

• **A constant flow**—While it will be difficult to apply the technological building-block philosophy until the cost overruns of the major systems now under development are brought under control, or until these systems move into the inventory or are cancelled, the groundwork is being carefully laid. Before a system is approved for engineering or operational systems development, the major technical problems will have been solved and—ideally at least—some proven components will be available for use in the system.

The cost and schedule should also be reasonably predictable at this point. As a result, Defense officials feel, more money will be available to pursue research and exploratory developments.

Initially, the good ideas come from a broad assault on the frontiers of technology. Once these ideas have been identified, parallel approaches can be taken and relatively large amounts of money can be spent in exploratory development. Then, by relating military requirements to the more promising of these developments, test or experimental hardware can be built in advanced development.

The technological building blocks are then available for incorporation into a weapons system. A technical development plan and project definition together provide the basis for engineering or operational system development. ■

Categories

RESEARCH

Aims at solving fundamental problems in the sciences. It seeks out and provides basic knowledge and theory for work which may lead to military capabilities.

ELEMENTS

Physical Sciences
Environmental Sciences
Mathematical Sciences
Psychological & Social Sciences
Biological and Medical Sciences
In-House Laboratory Independent Research
Research Laboratory Support

FUNDING (millions of dollars)

	FY '64	FY '65
Army	81.5	89.3
Navy	136.3	149.1
Air Force	84.5	93.0
ARPA	34.7	44.6
TOTAL	**337.0**	**376.0**

EXPLORATORY DEVELOPMENT

Applies knowledge and theory toward technical solutions of specific military problems. Techniques, feasibility demonstrations and experimental components are the prime products which may improve existing forces or point the way to new capabilities.

ELEMENTS

ARPA
Project Defender
Project Vela
Project Agile

ARMY
Applied Research — Rocket Propellants
Chemical-Biological Weapons
Nuclear Effects Investigations

NAVY
Non-Nuclear Air Launch Systems
Missile Propellants, Guidance & Countermeasures
Command and Control

AIR FORCE
Space Guidance, Flight Control, Propulsion, Life Sciences & Electromagnetic Techniques
Advanced Tactical & Strategic Missiles
Propulsion Cycles for Hypersonic Manned Systems

	FY '64	FY '65
Army	243.0	243.5
Navy	343.6	337.2
Air Force	305.0	308.0
ARPA	237.0	238.0
TOTAL	**1,128.6**	**1,126.7**

ADVANCED DEVELOPMENT

Is a selective extension of the exploratory development program, involving development of major experimental hardware items for solution of specific military problems.

ELEMENTS

ARMY
Antitank Weapons Systems
Army Air Defense System — 1970
Ground Environment for Military Communications Satellite

NAVY
Project Artemis
Fast-Reaction Integrated Submarine Control System
Project Trident
Air/Surface Fire Control System
Satellite Communications

AIR FORCE
All Weather Tactical Air-to-Surface Missile
Advanced Re-entry & Precision Recovery
Low-Altitude Supersonic Vehicle
Manned Orbiting Laboratory

	FY '64	FY '65
Army	80.2	71.5
Navy	134.6	175.6
Air Force	396.5	351.3
TOTAL	**611.3**	**598.4**

MANAGEMENT AND SUPPORT

Provides civilian manpower, technical materials and contractor assistance required for management and operation of the R&D organization (test centers, ranges and other technical facilities).

Research & Development

PROJECT DEFINITION

Project definition is the process whereby, with reasonable precision, a proposed weapon system is defined with regard to performance, schedule and cost.

	FY '64	FY '65
Army	170.3	182.6
Navy	201.0	217.9
Air Force	654.6	656.4
TOTAL	1,025.9	1,056.9

ENGINEERING DEVELOPMENT

Includes the programs under development for service use but whose procurement for inventory and deployment has not been approved.

ELEMENTS

ARMY
- Nike-X
- Lance
- TOW

NAVY
- Transit
- Sea Hawk Quick-Reaction ASW Weapon
- Medium Range Guided Air-Surface Weapon

AIR FORCE
- Titan III
- MMRBM
- Advanced Strategic Manned Aircraft
- Advanced Ballistic Re-Entry Systems

	FY '64	FY '65
Army	744.9	754.2
Navy	232.7	226.0
Air Force	767.5	672.7
TOTAL	1,745.1	1,652.9

OPERATIONAL DEVELOPMENT

Is directed toward development, engineering and test of complete systems which have been approved for production and service use.

ELEMENTS

ARMY
- Redeye
- Shillelagh

NAVY
- Polaris
- Subroc
- Asroc
- Dash

AIR FORCE
- Minuteman
- Space Track
- TFX
- C-141

	FY '64	FY '65
Army	102.7	55.9
Navy	496.8	345.2
Air Force	1,417.2	1,178.6
TOTAL	2,016.7	1,579.7

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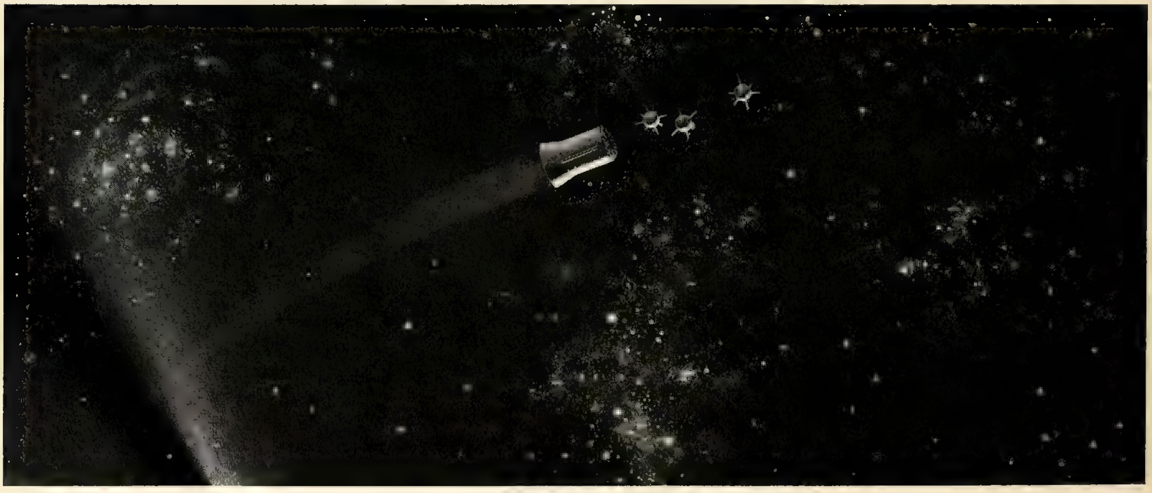

Research Chiefs 'Sophisticating' Their $1-Billion-a-Year Business

Key advances gained in past are being documented to bolster R&T case before Congress and provide guidelines for future

TRAINING their biggest guns on the management problem, Director of Defense Research and Engineering policy makers in research and technology have started to look backward a number of years to see what they did right in research and technology to get present-day weapons systems.

Object: to use past experiences as a guide for building a technical organization able most effectively to direct the Defense Department's annual $1.5-billion program of research and technology into channels that 10 to 15 years from now will carry the best weapons systems in the world.

At the same time, the Office of the Deputy Director (Research and Technology) has chartered its Assistant Director (Research) to set up broad research guidelines for in-house laboratories. Based on DOD's overall defense mission, these guidelines are supposed to lead to the biggest payoffs for the nation.

The Assistant Director (Research) has already called upon knowledgeable people in government research laboratories for help in drawing up the guidelines, and expects increasingly to bring small cadres of laboratory experts up to the DOD level to help DDR&E make technical policy decisions.

On another front, the Deputy Director's office is starting the third phase of a program aimed at increasing the efficiency of the in-house laboratories. Unlike many other programs with the same avowed goal, the current one is more apt to make changes in DOD in line with the laboratories' needs than to make changes in the laboratories to fit a preconceived DOD structure.

Out of this concerted effort to put management of DOD's research and technology on a scientific basis, industry probably will get what it has been calling for: "a sophisticated customer." In turn, the government will probably find itself drawn closer to industry and its problems.

CHALMERS W. SHERWIN, Deputy Director for Research and Technology.

- **Looking backward**—Congress appropriates money for equipment at about the level of request, but not for research and technology, a DOD official pointed out. He indicated that the legislative body is not fully convinced of the value of the research function. There is good reason for this attitude; as yet, nobody has adequately documented the part research plays in the development of weapons systems.

The case for research can be stated objectively: it takes a certain sized warhead carried by a certain type vehicle guided with a given accuracy to kill so many people or decimate a certain amount of land. From these data, investigators can work backward to find out the applied and basic research that was necessary to evolve the weapons system. This is one of the paths DDR&E wants to trace to prove the value of research.

With this documentation in hand, DDR&E can go after more research money from Congress and have a good chance of getting it.

In specific terms, DDR&E is trying to find out what *key advances* emerged from research—such as a new-type transistor or a better nozzle for a rocket or a better gyro—to contribute to modern weapons systems. In another example, what has basic research taught about the ionosphere that perhaps has resulted in a better military weapon for the U.S.?

DDR&E expects to find hundreds of key advances. It expects to prove its case for research many times over in terms of existing weapons alone. "If, for example, we designed the *Minuteman* with the technology of 1950, it couldn't have taken off," noted a DOD scientist. "If it were able to take off, it would have burned up. If it did not burn up, it would never have had the accuracy to make it a feasible weapon."

One of the most important key advances—development of the thermonuclear warhead—radically cut down the size of modern missiles. Even if this advance were entirely discounted, key advances in re-entry physics and materials, solid-state devices and such would be considered. They all contributed significantly to the ability of a modern weapon to seek out and destroy its target. If, for instance, through an electronic advance, the accuracy of a weapon is doubled, its effectiveness is increased four times.

"We expect we will be able to build

a big case for research," a DOD scientist concluded. "Also, we will be able to find 'patterns of productivity.' "

● **Building on the past**—These patterns will probably indicate a means for more efficiently managing research. DOD is looking for those properties of government-managed research that are necessary for high productivity and creativity. Once they are learned, DOD expects to be able to spend its future billions of dollars more effectively.

Some patterns are foreseen: DOD must work more closely with industry on the local level. DOD in-house laboratories must be delegated authority, have improved lines of communications up to the policy-making level, and maintain a high morale.

On the other hand, industry is criticized for not taking full advantage of government-sponsored research. Companies seem reticent about using ideas other than their own. Although the nation suffers in the overall picture, some bright spots are put in by imaginative firms. There was, for example, a symbiosis between the University of Illinois and Minneapolis-Honeywell in the development of the electrostatic gyro. The original idea for the instrument came from the university working under a government contract. The government subsequently backed the company's development of the gyro, which was extremely successful.

Such productivity is prompting several universities to set up programs to exploit their research jointly with commercial organizations. This is another of the patterns of productivity involving a key advance that DDR&E is trying to document.

● **The management problem**—Chalmers W. Sherwin, Deputy Director (Research and Technology) emphasizes the need to find ways for the government to take long-term risks where the payoff promises to be really large. He observed that the government that does not use its research resources effectively will not come out ahead of its foes.

"What we will be doing in the next decade depends on how well we administer research today, and our studies will make the case for Congress to see what they are buying," he said. "We should be limited only by (the supply of) good ideas and people, not by money."

Thus, the fundamental problem facing the Deputy Director is to build a professional scientific management for research and development. The office needs a good research organization and a plan of action. Yet the management of large-scale R&D projects is only about 20 years old.

"This is a new science in its own right," a high-level DOD official said, "and scientists themselves should recognize the revolution that has taken place in R&D scientific management."

● **At the working level**—Basically, DDR&E controls the in-house efforts of the three military services, of their laboratories and of DOD's staff of technical experts. The job is to make the operation run efficiently and with the proper delegation of authority.

In order to do this, "we first have to spend time with the laboratories and the technical services," said a DOD official. "We should be concerned with the state of (professional) health of the working level scientists and engineers. Right now, we are working on improving and analyzing DOD's laboratories; this is being done in Task 97, under Edward Glass (special assistant to the Deputy Director [Research and Technology])."

These laboratories are industry's prime contact with DOD. The DOD official stressed, "In research, the real payoff is local control of the money—where there is people-to-people talk where the work is being done."

On the policy-making level, DDR&E has the problem of recruiting a staff familiar with military needs, government laboratories and a field of technology. For this reason, the main strength will be taken from the service laboratories. Asked if the men recruited might tend to dictate to the laboratories on technical matters, a DOD official said he didn't think so, "that these men know the evils of central management and the degree of autonomy or responsibility that laboratories should have in order to do their best work."

● **Background for decision**—Relatively few of the people brought into DDR&E to help make technical policy decisions will be working there full time. Instead, they will be encouraged to retain their laboratory ties, but at the same time will be part of DDR&E discussion groups deciding how much effort should go into particular phases of technical work. This is said to be a new approach to setting guidelines for DOD's research efforts.

In a typical example, a group might analyze the amount of money going into nuclear physics, and the question might be raised: are we putting too much into high-energy physics or should more money go into low-energy physics for the biggest payoff?

DDR&E is striving in its discussion groups to get a representative mix of the various technical disciplines. Somebody might propose a problem in atmospheric physics, for instance, and others around him are then forced to discuss it and analyze it. In this way, DDR&E will be building up a form of internal technical management and consultants for DOD research.

The real issues are:

—What has come out of the billions of dollars spent on research and exploratory development over the past few years?

—What should be the present level of research effort in DOD?

—How can this money be spent to the best advantage for the long-term defense of the U.S.?

Answers to these questions will probably be easier to get once the expected key technical advances are documented, patterns of productivity traced and management lines made more flexible and drawn shorter.

● **Guiding DOD research**—The Office of the Assistant Director (Research) was recently reoriented to set up broad guidelines for both contractural and in-house programs in DOD research. This is a change from the office's previous method of concentrating its efforts strictly on problem areas—management by exception.

"We're going to develop research guidelines through reviewing and analyzing DOD's present needs as well as potential future ones," Edward M. Reilley, Deputy Assistant Director (Research), told MISSILES AND ROCKETS. "Then we shall delegate to the services below us the maximum flexibility in carrying out their work along the indicated paths."

The discussion groups mentioned earlier will play a large part in outlining DOD's research programs. The groups are going to be asked: where are key advances needed most and what are they? Such advances will be considered in each of four major program areas.

The first program area, that of physical and mathematical sciences, is divided into four sub-areas: general and solid-state physics, nuclear physics, chemistry and mathematics.

Similarly, engineering sciences are divided into electronics, materials, mechanical, energy conversion and information sciences. This last category may not be considered separately.

Life sciences are made up of the biological, medical and behavioral sciences. And the environmental sciences comprise Earth sciences, atmospheric sciences, oceanography, and astronomy and astrophysics.

Since the Office of the Assistant Director (Research) is aiming at applications, it prefers not to use the phrase "basic research" in describing its mission. Yet the office intends to lay policy for "that research which has no direct and clear application." Emphasis is on the words "direct and clear."

"Actually, we think the difference between basic and applied research is in the attitude of the sponsor," said an official in the Assistant Director's office. "Applied can be just as basic as basic

"The blood more stirs
to rouse a lion
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research even though the sponsor may have an end in mind." He stressed, "It's the relationship rather than the application of research that we are looking into."

He suggested an example from the category of physical and mathematical sciences: fundamental research on the growth of crystals can be as basic as an investigator wants to make it. Not much is known about growing crystals—it is an art. "So we can say there is no *direct and clear* application of crystal-growing in DOD. However, we spend enormous amounts of money on crystals—semiconductor crystals, laser crystals, quartz. And the better we understand the science behind crystal technology, the less 'cookbookery' we'll have to use. Besides, cookbookery is dreadfully expensive."

- **A fine line**—In another example, taken from the life sciences, the studies of the composition of human blood—physiological, chemical and cellular—is as basic a research study as one can find. Yet one of DOD's major problems is blood preservation in wartime and for disasters. "So everything we know about the basic problem will be able to be related to the applied problem—to a point where it is difficult to tell which is applied research," the official said. He observed that on this basis, "practically all DOD research can be construed as applied."

These have been two examples in which there is very little science, although the dollar magnitude of DOD programs relating to them is very large.

The engineering sciences offer many examples in the energy conversion field. For instance, the detailed laws of chemistry and physics and how they relate to hundreds of energy conversion devices are ill-defined. The logistics of supplying the Army with energy sources to almost any location in the world is an expensive job: a gallon of diesel fuel, for example, delivered to north Alaska by air can cost a couple of dollars a gallon, not the eight or nine cents it costs here.

Simply for economic reasons, therefore, there is active DOD interest in exploring all physical and chemical processes which would make energy cheaper and more available in small units in the field. This interest includes thermoelectricity, fuel cells, chemical interactions at electrodes, plasmas, thermionics and others. The aim is to reinforce an art by science.

Very often, technicians operate from general principles, but not in their detailed scientific work. They may find, for example, that the thermal efficiency of a cycle is 90% without knowing the figures of merit which when multiplied together would give 90%. A science that cannot operate from detailed laws is an immature science.

In the fourth major program area—environmental sciences—the DOD official suggested the field of seismology as offering work that can be basic or applied, whichever way an investigator cares to look at it. DOD is interested in gaining a thorough knowledge of the structure of the Earth, particularly where a branch of seismology touches on the problem of detecting nuclear detonations at great distances.

Also, an aspect of oceanography with its concommitant problems of sound transmissions as it relates to ocean dynamics and composition is of vital interest for submarine detection and communications.

Thus, DOD in its future research will be emphasizing the backtrack to "basic research." The amount of support will be in proportion to the national interest. The Advanced Research Projects Agency, for example, is particularly concentrating on seismology because of the agency's mission in the nuclear detection field.

Yet the Office of the Assistant Director (Research) will not manage research on a project level. This would be physically impossible and financially foolish. The office will put all its effort to setting up research guidelines, seeing that the DOD research effort is oriented along them, but with the fullest allowance for local flexibility. Still, there will be management review by the office. It is said that this is the first time DOD will have managed its research program in this exact fashion.

- **Helping the in-house labs**—The Dept. of Defense is now taking a hard look at its in-house laboratories to make them more effective research instruments. This is the mission of Task 97, run by Edward Glass, special assistant to the Deputy Director (Research and Technology). Glass told M/R, "We are trying to increase quality, not the quantity of in-house work."

The idea was colorfully expressed in a special study of in-house Army laboratories: "What (our) laboratories need is not a tank car of lukewarm water, but two quarts of boiling water."

Glass related that Phase 3 of the program is starting now. In Phase 1, called manpower and personnel, the job was to solve the morale problem that, perhaps through red tape, had been tied in knots for many years. The technique used was simple but effective. In-house laboratories were visited, the problems collected and subsequently analyzed. A typical one was the complaint by a field laboratory that its personnel could not rise above the Civil Service classification GS-13.

Meetings were held at DOD with representatives of all interested agencies attending. The problems were presented

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and many of them solved on the spot. "It was simply a matter of communications," Glass said.

Phase 2 is concerned with fiscal problems. Started last April, the final report is being finished now.

The latest phase is concerned with the military construction of laboratories, including policies, procedures and procurement; supporting services; and a look back at Phase 1 to see if the laboratories have maintained the ground they won.

- **In-house labs help industry**—Glass sees the laboratories as a prime manager of DOD's technical programs. The labs have to translate the operational needs of the military into technical requirements. In effect, the labs are there to interpret what the military man says he needs into requirements that can be handed to industry.

In addition, the labs are said to be the best windows through which to watch government-contracted university research. When it reaches the point of military usefulness, it can be gathered for industry processing into weapons systems.

DOD has not yet analyzed how much of its in-house work could be done more effectively by industry. It appears that once a laboratory has hold of a research project, attrition is the only way it may be lost. This means that when new projects come in through the front door, the limited size and budgets of the labs dictate that some older projects will have to leave through the rear door.

It is claimed, though, that the labs must do certain work: highly dangerous research or production, highly classified, and highly expensive.

The labs are also said to be useful for defining the problems before they are turned over to industry. Furthermore, the laboratories often open new areas to industry, ones that may have been ignored because of other research bandwagons passing at the time.

The labs, moreover, help industry go into these unorthodox areas. The scientists at the labs will often personally work with industry's representatives on specifications and technical problems.

Thus, DDR&E is trying to crash through the research barrier by a frontal attack. Modern weapons are being analyzed to see what key advances brought them into being. In turn, key advances are being analyzed for the light they may shed on patterns of productivity. At the same time, DOD is looking deep into its in-house laboratories with the intent of applying suitable patterns to bring about advances that will assure the U.S. of having the world's best weapons systems now and for the foreseeable future. ■

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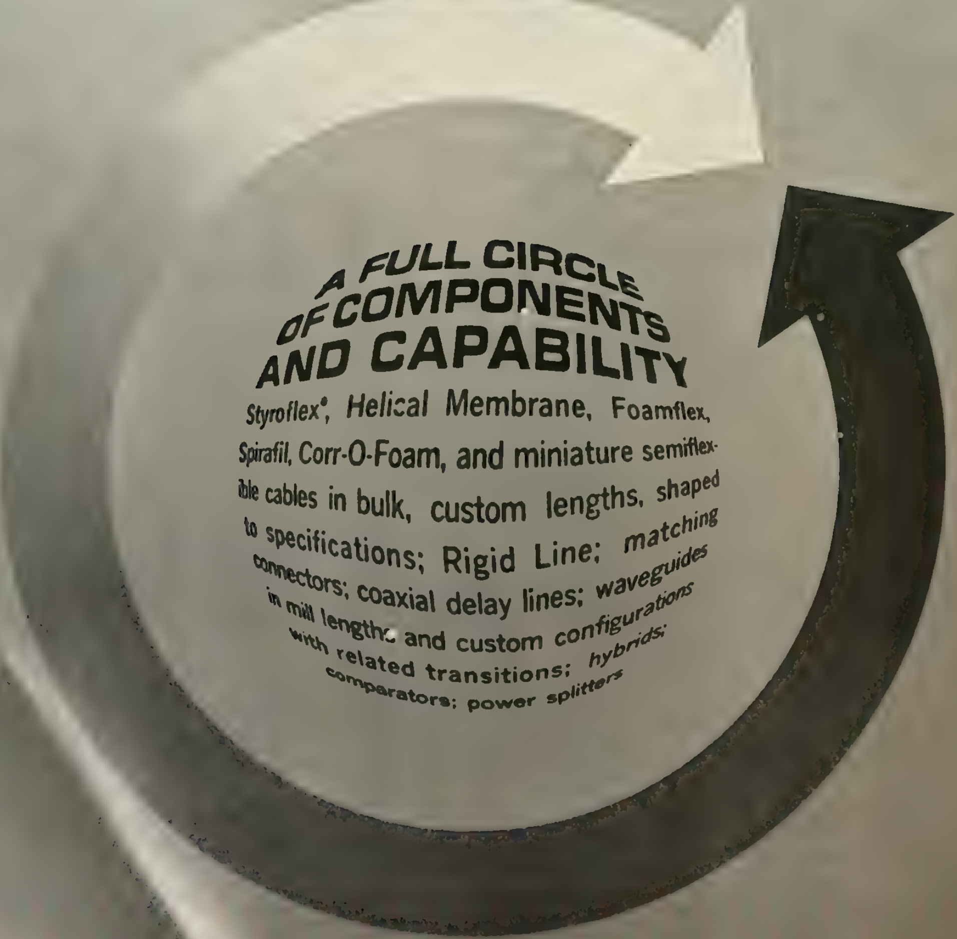

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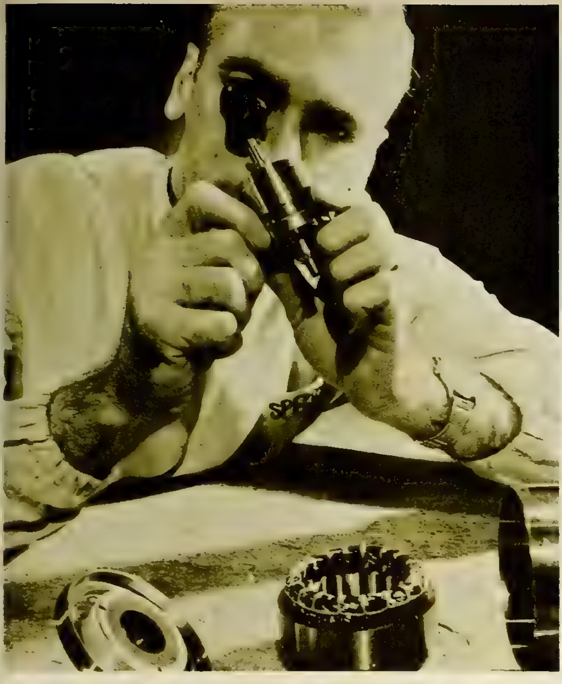
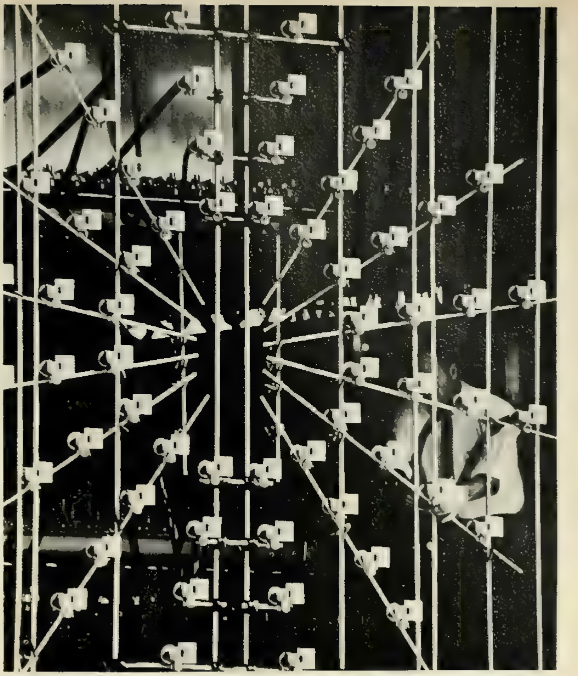


KEY TO successful guidance for Army's new Sprint high-acceleration A-ICBM could rest with development of reliable inertial elements such as this high-g fluid-rotor gyro by Sperry.



DDR&E emphasis on missile/space detection and tracking has brought rapid advance in phased-array radars such as this 64-element, self-focusing unit by Electronic Communications, Inc.

DDR&E/research & technology

Electronics Priority Given to A-ICBM, ASW, Command & Control

Projects controlled by directorate to top $1 billion in value in FY 1965; a survey of areas now getting principal attention

ELECTRONICS SUPPORT of anti-ballistic missile defense systems, anti-submarine warfare, command and control and nuclear-burst monitoring head the R&D list in the Office of the Director of Defense Research and Engineering.

Total electronics R&D throughout the defense establishment is estimated to exceed $3 billion for Fiscal 1965. Identifiable research projects in the electronics field controlled by DDR&E are valued at about $800 million for FY '64 and will exceed $1 billion in FY '65.

No single authority exists in DDR&E today having full cognizance over electronics, nor is there any set formula for determining which office controls what effort.

Electronics responsibility generally is in the hands of the Deputy Director for Research and Technology, Dr. Chalmers W. Sherwin. More specifically, it is handled by his Assistant Director (Communications-Electronics), Thomas F. Rogers. Rogers is assisted by two deputies: Ernest C. Wood (Electronics) and Willie L. Moore (Communications).

In its charter, Rogers' office covers the entire electronics components and equipment spectrum.

The separation of "electronics" from "communications" is as follows: communications covers all equipment at a terminal—including transmitters, receivers, multiplex and other signal processing subsystems necessary for the transmission and reception of telecommunications; everything beyond that functional equipment division falls under electronics. Data processing, tactical or strategic, is electronics. Communications includes techniques and systems.

It is in the area of support to other DDR&E offices that Rogers' responsibility becomes hazy and is handled on a project-by-project assignment basis. Robert H. Sherer, Assistant Director (NMCS, TS, Strategic Command and Control) is responsible for overseeing DOD strategic C&C development. Rog-

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ers' office provides support for systems, but could be assigned cognizance over a particular hardware development. The same is true for tactical C&C and for Dr. Albert C. Hall's space systems office.

Because of the diversity of fields covered in DDR&E electronics R&D management, it would be impractical to detail future needs in each. In the following, MISSILES AND ROCKETS summarizes those areas currently enjoying the greatest emphasis—both in funding and effort.

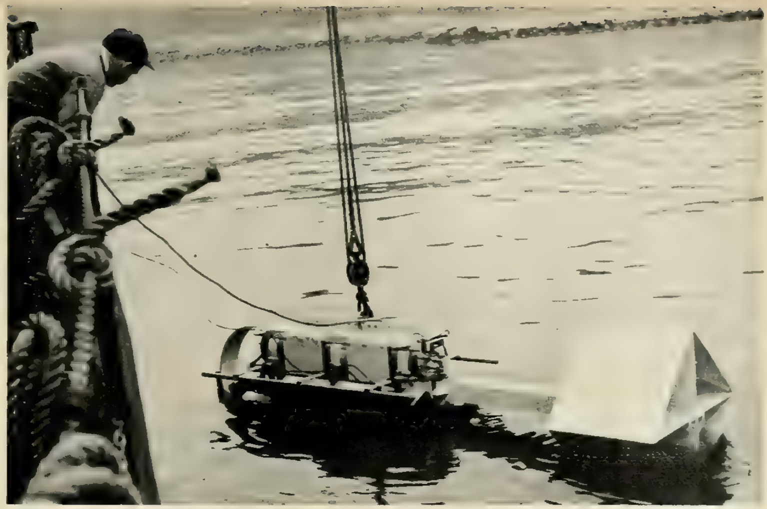
- **Detection and tracking**—In testimony on the military posture in late January and early February before the House Armed Services Committee, both Defense Secretary Robert McNamara and Dr. Harold Brown, Director of Defense Research and Engineering, stressed the urgency of developing adequate defense against ICBM's and submarine-launched IRBM's. To this end, an intensive R&D program is being directed by DDR&E, and will probably extend at least through the next five to 10 years. A significant portion of this effort falls into the area of electronics.

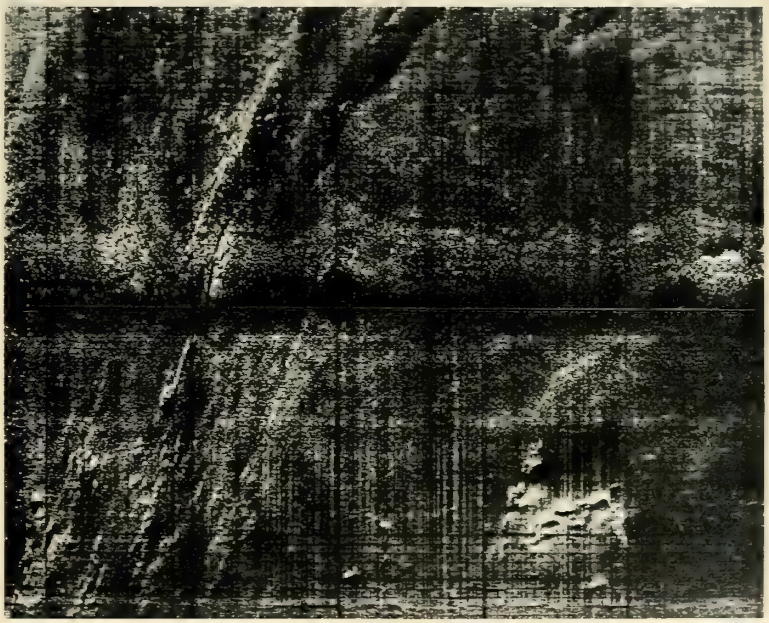
Roughly $0.5 billion has been requested by DOD for FY 1965 for two programs: *Nike-Zeus/Nike-X* for antimissile defense against ICBM's and IRBM's; and Project Defender. The latter is a many-faceted research effort involving advanced radar and non-radar discrimination-sensor techniques for the detection, identification and tracking of both re-entry bodies and orbital satellites.

Defender also includes studies of highly advanced methods that offer a potential for active missile defense. The laser some day could fit into this area. Dr. Sherwin, deputy director for research and technology, suggested that for the future there is a need for development of a weapon or weapon technique for use against equipment—that is, one capable of rendering equipment temporarily inoperable. The proper harnessing of electromagnetic energy may yield such a system.

Discrimination, now believed to be a solvable problem within a practical time period, still represents a main hurdle for *Nike-Zeus*. The anticipated backup, however, expected to be available with *Sprint* in the *Nike-X* low-altitude ICBM intercept approach and the multi-target tracking capability of the Multifunction Array Radar make the whole defense approach considerably more attractive.

Much must be accomplished before all the technical problems are solved for such an antimissile system. For example, as one official pointed out, *Sprint* and *Zeus* are expected to be capable of multiple launch against a number of targets. Will the effect of the first antimissile burst preclude detonation of other defense missiles that might of necessity be within burst-radiation range? Such questions must still be resolved (within the bounds of the test ban).





ADVANCES IN UNDERWATER surveillance, detection and tracking are urgently needed by the Navy. Support for this effort is being drawn from an expanded oceanography program. Typical of new equipment now required is this Westinghouse-developed ocean-floor, side-looking sonar, built for the Office of Naval Research. Shown being lowered (top), the instrument will be towed 200 to 400 ft. above the ocean floor at depths to 20,000 ft. Range is 2,400 at right angles to the direction of tow. Three-dimensional picture (bottom) shows the Atlantic floor at 8,400 ft. Area covered is one-half mile wide by one mile long. Resolution is to 2½ x 4 ft., search rate 1.5 sq. mi./hr. An early version was used in the search for the missing submarine USS Thresher.

Not only will flight electronics have to be "hardened," but some ground-control and data-processing electronics also may have to be designed for greater radiation resistance.

Complementing *Zeus/Nike-X* is the Army's *AADS-70* (Army Air Defense System 1970's). Funding is still low (only $5 million for FY '65), but the program so far has the blessing of DDR&E and is expected to increase.

It has been proposed by DOD officials that *Nike-X* could also be an effective weapon against submarine-launched shorter range ballistic missiles. It would help considerably to at least know from what direction an attack might come. Also, a greater deterrent might be to locate and destroy the submerged launching platform before it could fire a second missile.

Two programs are being conducted by the Navy under DDR&E control to solve this problem. Trident is the designation for an R&D effort to develop a long-range submarine detection and tracking system by passive techniques. Similarly, Project Artemis is a complementary approach that will make use of active long-range detection techniques.

The Ballistic Missile Early Warning System is now considered fully operational. The three stations, located in Alaska, Greenland and England, are situated in such a manner that they sweep overlapping sectors covering most of the northern regions from which a ballistic missile attack might be launched—today. However, an attack might someday be launched over the southern part of the globe.

Thus, an omnidirectional backup system is desirable. Over-the-horizon radar may be one solution. This project was funded by DOD in FY 1963 and shows great promise, not only as a means for covering the exposed U.S. "rear," but as a BMEWS backup system. The system employs a brute-force HF radar beam to produce back-scattered target information. Signal processing techniques remain a key area for advancement.

Other approaches may, however, be proved more practical. The employment of satellite detection together with satellite-to-satellite communicaions for instantaneous relay to U.S.-located ground stations might prove to be as effective and cost less on a long-term basis.

The point is, said one official, DOD is and will be open to any good new approach to these problems.

- **Electromagnetic interference**—Not a large national effort, but nevertheless an extremely important one is the tri-service effort directed by the Electromagnetic Compatibility Analysis Center at Annapolis, Md., for DOD. The radio frequency interference problem is steadily worsening, says one official, and the end is not even in sight. ECAC is concerned chiefly with the problem of self or "friendly" interference.

The other side of the problem is unfriendly interference—electronic warfare.

DDR&E is attempting to establish a broad base over the entire EW field to improve weapon systems capability, to assure non-interruption of the National Command and Control System and to strengthen tactical C&C.

It is hoped that the first problem, electromagnetic compatibility, will be on its way toward solution when sufficient data are collected, analyzed and understood concerning the effects of densely populated emitters. In the meantime, DOD will continue to stress to industry the need for black box-by-black box RFI isolation.

Considerably more information, however, is needed concerning the variables of operating environment power, propagation modes and solar influences.

The problems of intentional RFI are equally demanding. Their effect on both tactical and strategic communications could be disastrous. Similarly, all radio-controlled weapons, whether active or passive, are more subject to misdirection by properly transmitted radio signals, general jamming or by pulse-type radiations resulting from local nuclear bursts.

One key problem with *MMRBM* guidance requirements has been that of developing a star tracker system capable of continuous track through the

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period of highest pulse intensity following a nuclear detonation. Reportedly, this problem remains unsolved.

Anti-radiation missiles may also be subject to misdirection by manipulation of propagation from the target radar. This is an area of research not yet seriously investigated, but it is expected that DDR&E will agree to such a study in the future (probably under Air Force sponsorship).

- **Radiation/seismic sensors**—The nuclear-test moratorium has prompted a new area of R&D—nuclear-detection sensors. Employment of such devices will be both ground-based and satellite-borne. Research in theoretical and exploratory nuclear technology is being pressed by DDR&E now, and is expected to continue for many years (barring negation of the treaty).

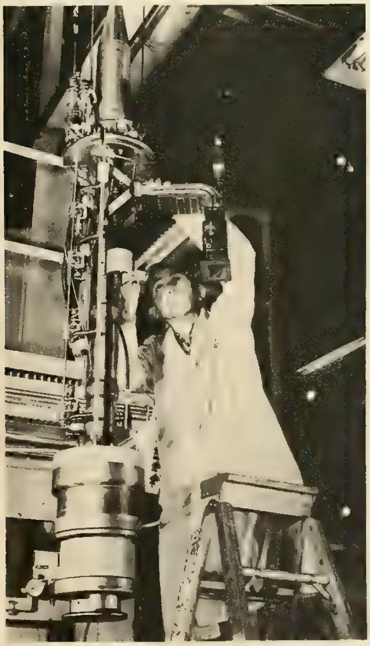
Different support sensors and measurement equipment will be needed for the planned series of deep underground nuclear tests in Nevada to be performed by the AEC for DOD. Besides laboratory test equipment, sensors will have to be improved for blast effects, such as shock-wave propagation (in air, ground and water), thermal and radiation, electromagnetic-pulse and biomedical phenomena. Systems and component damage vulnerability will be an extremely important area of investigation, particularly in electronic equipment.

- **Laser R&D pressed**—The development of lasers for weapons, communications, range finding and tracking is being pressed by DDR&E through the services—particularly the Army and Air Force. The impetus thus provided has served as a catalyst in industry, one official pointed out, and will pay off over the next 10 to 15 years as the size of the effort increases.

Newer areas of application now being studied include identification and navigation devices and the futuristic optical computer and data-processing system (employing optical frequencies). New laser materials, better lens configurations and new techniques for applying both pulse and CW lasers will be sought during the decade by DOD.

An effort is now under way by Dr. Sherwin and his staff to take another across-the-board look at laser research sponsored by DOD and provide general R&D control to minimize duplication and to assure proper balance of effort.

- **Command and control**—Concern with developments during the last four years in the field of command and control has resulted in a major reorientation of the program direction by DOD. There has been considerable progress in recent years; however, there is a general feeling among DDR&E officials



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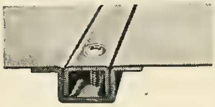

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that the hardware aspects may have been oversold to industry.

Said one official in summarizing the state of C&C today: "It's been overstaffed, overfunded and underdone." This may be also an oversimplification; however, emphasis has now shifted to determining what the user needs and what the user can use—not what machine can be developed to replace or confound the user. More effective use of what now exists is the byword.

- **Data processing**—The whole field of electronic computation and automatic data processing has drawn its strength from DOD needs in the past and will continue to be a prime mover for advancing the state of the art.

If any one new machine is needed for C&C, said a DOD spokesman, it is in the area of data storage and retrieval. Many ideas have been investigated and some useful instruments have been built (such as the IBM Walnut system at San Jose, Calif.), but so far all are too limited or too specialized.

Microelectronics will be pressed into use as soon as possible, DOD feels, yet industry must make its own way at its own speed. Size reduction will permit practical increase of capability, and the move to higher frequencies and new optical techniques will both increase operating speeds and expand the range of practical applications.

Automatic photo interpretation, machine translation, intelligence analysis—these are areas in which step advances are needed, not just at the DOD level, but throughout the field forces.

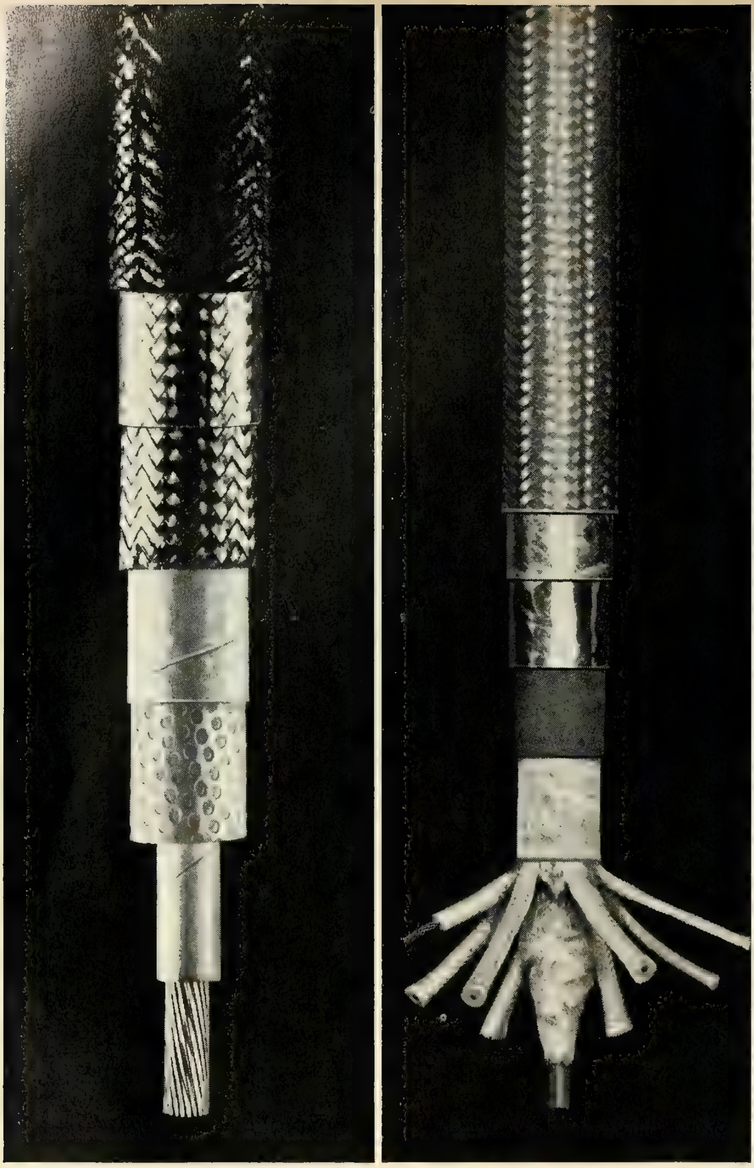
Bordering on this need is the urgency of information exchange in defense research. A center, such as that used so successfully by NASA, may well be a solution, but the great size of the defense field will necessitate development of a ready access, foolproof depository.

- **Guidance and control**—The one field that may never cease to offer a full range of R&D is that of guidance, navigation and control of aircraft, missiles and space vehicles.

There is a trend now toward standardization, but this is still only in areas of application enjoying use of all-purpose or multifunction hardware.

Stellar guidance, Ships Inertial Navigation Systems, maneuverable spacecraft and re-entry bodies, low-level penetration G&N and terrain-avoidance radar are typical examples of systems requiring continual updating. Stabilization and attitude sensing devices will continue to draw DOD R&D support.

Para- or diamagnetic rotor suspension in advanced gyros still seems to offer the best early advance in inertial instruments, but research is still being pressed in more exotic areas, such as nuclear-spin and solid-state gyros. ■



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DDR&E Opens International Defense Markets

CONTRACTORS now have an increased opportunity to sell their products abroad, thanks to a new program initiated in Department of Defense Research and Engineering.

The new DDR&E effort in International Programs, headed by Ronald M. Murray, is less than a year old. Three European countries have already signed on and a fourth is said to be considering joining. The countries now in the program are Britain, West Germany and France.

For missile/space contractors, the prime opportunity will lie in electronics, since cooperative programs in nuclear weapons and military space programs are prohibited by law. However, aircraft, aircraft engines, Army vehicles, and Navy missiles, ships and aircraft are included in the agreements.

There are three levels of cooperation in the program:

—*Coordinated*—Two countries swap information or results from their own separate projects. Neither is dependent upon the other, but they benefit by the knowledge they acquire. Various studies of lasers, for example, might fall into this category.

—*Cooperative*—Two countries share work or funding of some portion of a project, but are not critically dependent upon the other. The U.S. interest in V/STOL aircraft is an example.

—*Joint projects*—Two countries share both work and funding, and are critically dependent upon one another. The U.S. is currently participating in the joint development of a tank with West Germany on this basis.

• **How to sell**—Murray says the program will greatly increase the selling potential of U.S. contractors when the items developed go into production. He gives this advice to industry:

(1) Get in on the ground floor here by bidding on the projects as the services let them. Although procurement is done by the individual services according to their interests, the projects are identified as being in the International Programs category.

(2) Sponsor institutional advertising abroad, so that the foreign governments know your capabilities.

(3) Form industrial ties with firms in the participating countries, either by establishing subsidiaries or through joint ventures.

Production rights will be apportioned to the participating countries commensurate with their respective contributions to the project, Murray said. Industry's position in the program is now being studied in detail by a subcommittee of the Defense Industrial Advisory Council (DIAC) to determine what policy should apply in the release of technical information, and what kinds of things should be made available to the European partners.

In addition, Murray said, another DIAC subcommittee will look at the relationships of DOD, the services and industry in this matter.

He pointed out that there will be some change in traditional roles; since the government takes a stronger hand in determining the research and development program, it will tend to lessen the sales impact of individual companies.

For instance, if the U.S. and Germany agree on a specific component, it will make it difficult for a company to sell another kind. This is why the company is in a better position if it participates in the original program.

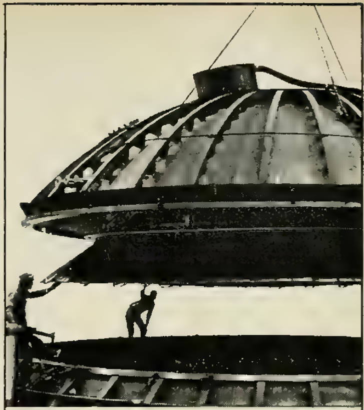
• **Full partners**—Murray stressed that this is not a "give-away" or aid program. Only countries with levels of research and development effort comparable to those of the United States will be accepted. This program replaces the now-defunct Mutual Assistance Program (MAP), and the ground rules are greatly changed.

For instance, this is not a program to build up the technology of other countries. To participate in a project, the other country must demonstrate a high technical competence in the area involved. There must be an established U.S. military need for the item, and it must give the U.S. a good return for its investment.

Projects are initiated by the services, and service RDT&E funds are used (although DDR&E must approve this). Competitive bidding on items is required, although DDR&E is studying how to fit this kind of requirement to financial structures in other countries.

Programs are negotiated at the DDR&E level. Defense Representative, North Atlantic and Mediterranean Area (DEFREPNAMA) acts as representative in Europe, directly assisting American industry in the European aspects of the program.

Objectives of DDR&E in getting into such a program are threefold: 1) to beef up the R&D effort on both sides; 2) to lessen logistics problems (for instance, if both countries use the same equipment, supplying one in the other's country will be considerably simplified); and 3) to enhance inter-operability and even interchangeability of equipment. ■



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Materials Studies Stress Non-Metals

Shift away from metals means refractory, inorganic materials efforts suffer; two-thirds of studies are done out-of-house

IDENTIFIABLE MATERIALS research and technology programs in the Defense Department are shifting in emphasis from metals to non-metals—at the expense of refractories and inorganic materials work.

Preliminary surveys aimed at establishing the current levels of effort indicate a movement into organic and composite materials even though specific identification of the total materials area is only about 50% accurate.

Since materials problems extend thorough all modern weapons systems, exact fundings of particular materials development is not easily ascertained.

Dr. Earl T. Hayes, assistant Director (Materials) in the Office of the Deputy Director for Research and Technology, DDR&E has identified about $100 million in current materials programs and estimates there is an equal amount in the materials area funded through other categories.

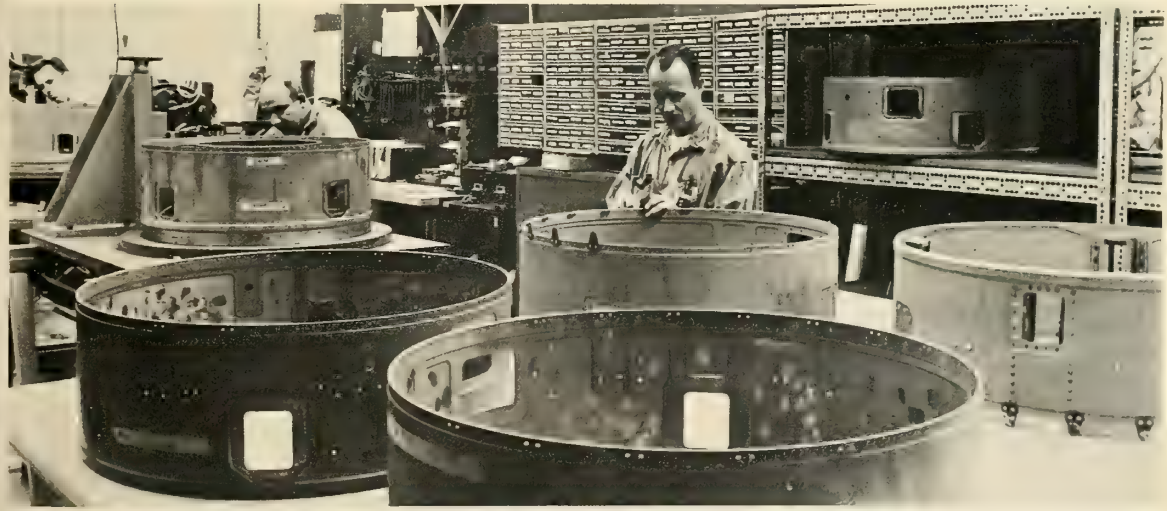
Specific areas of emphasis are pretty much up to the individual services, but knowledge of overall levels of interest is a powerful management tool in DDR&E since the funding has reached a plateau and may even slightly decline because of increasing overhead.

● **Service breakdown**—The sum total of DOD materials R&D is split between in-house programs and contracted effort—with about 66% going to universities, industry and non-profit research institutes.

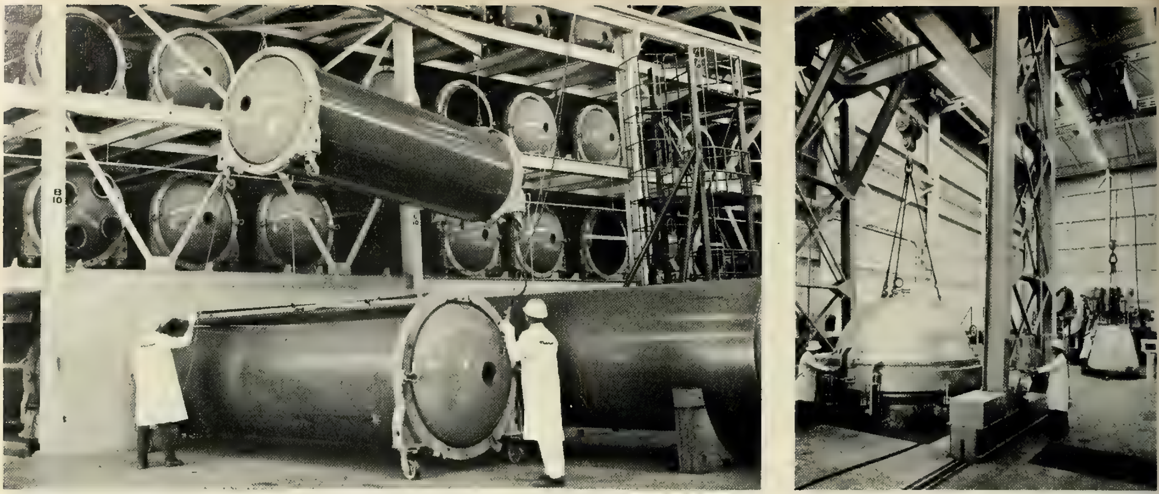
Materials work within the services is covered by 16 Navy, 19 Army and 4 Air Force laboratories. By far the largest service lab is the Air Force Materials complex at Wright-Patterson Air Force Base—accounting for 80% of the AF effort and about ⅓ of the entire DOD program. The Watertown Arsenal is the Army's biggest with about 25% of that service's work. The Naval Research Lab is the largest single Navy installation working in this field, but materials work is rather evenly distributed among a number of other facilities.

The Army and Navy farm out about half of their materials research, while the Air Force performs only about 20% of its work in-house.

The major concentration of metals work in the Army is centered at the Watertown Arsenal where programs cover improved ferrous alloys for ord-



BERYLLIUM spacers for Minuteman are replacing aluminum, saving more than 50% per piece in weight. Fabricated by Brush Beryllium Co., Cleveland, spacers are the first structural production units to be made from the lightweight metal.



LEFT: Minuteman motor cases are lined up before moving through loading and curing lines at Air Force Plant #78, operated by Thiokol Chemical Corp. Case construction, liner insulation and nozzles for the ICBM were once the object of a crash materials program. RIGHT: Materials and fabrication problems are still being faced in the nozzle area, but progress is being made, as evidenced by this manufacturing facility at Thompson Ramo Wooldridge Electromechanical Div., Cleveland. A 120-in. nozzle appears in background. This facility can handle parts measuring up to 200 in. in diameter.

nance purposes. The Arsenal also conducts most of the titanium work. There is a great deal of effort in developing processing techniques.

The light metals work is carried out by the Frankford Arsenal together with a heavy involvement in powder metallurgy. Organic materials are handled in the main by the Picatinny Arsenal with Rock Island covering elastomers for low-temperature radiation and insulation applications. Redstone concentrates on ablative plastics.

Redstone programs in non-metallic inorganics are pointed toward heat protection, nozzles, vanes and re-entry bodies. The bulk of electronic materials research is handled by Fort Monmouth with most of work being in inorganic non-metallics for semiconductors, ferroelectrics and dielectrics.

Preliminary studies show that 38% of the funded effort in materials is presently in metals. While Hayes admits there are no figures available, he feels the percentage in the past 10 or 20 years was more likely around 66% for metallurgy.

- **Current levels**—Refractory metals work constitutes about 9% of the metals total, and Hayes sees this as declining as greater demands are made for superalloys in turbine applications coupled with a resurgence of interest in titanium.

Titanium—a major item in materials R&D a decade ago—is finding increasing usage in all three services. The recently disclosed A-11 aircraft is one major example, as is the titanium second stage in the *Minuteman II* missile.

Approximately 22% of the identifiable DOD materials program is in organics with the major concentration in new plastics and polymers. The general trend is toward higher temperatures.

The development of better ceramic and graphite materials uses up about 11% of the money, and 20% is devoted to producing improved electronic materials.

The remaining 9% covers composites, and this area, together with organics, is expected to grow at the expense of metals and the inorganic programs.

Hayes says this growth pattern resembles that of the National Aeronautics and Space Administration's materials effort where the emphasis has been in organics.

These preliminary trends indicate to DOD specialists that the next ten years will see the emergence of a materials science acting as a composite for all of the classical groupings.

- **Spheres of interest**—In contrast to the Army's procedure, Navy labs do no contracting. This is handled by the Office of Naval Research and the Bureaus. The Naval Research Laboratory is the largest internal materials research center with its work divided evenly between basic and applied. NRL conducts applied work in radiation damage to metals, metallurgy of high temperature heat transfer systems, physical metallurgy and the processing of refractory metals and studies of weld-joint behavior. It is under the Office of Naval Research.

The NRL also handles work for the Bureau of Naval Weapons in metallic materials for armor and investigates welding, heat treatment, fatigue and radiation damage to ship steels for the Bureau of Ships.

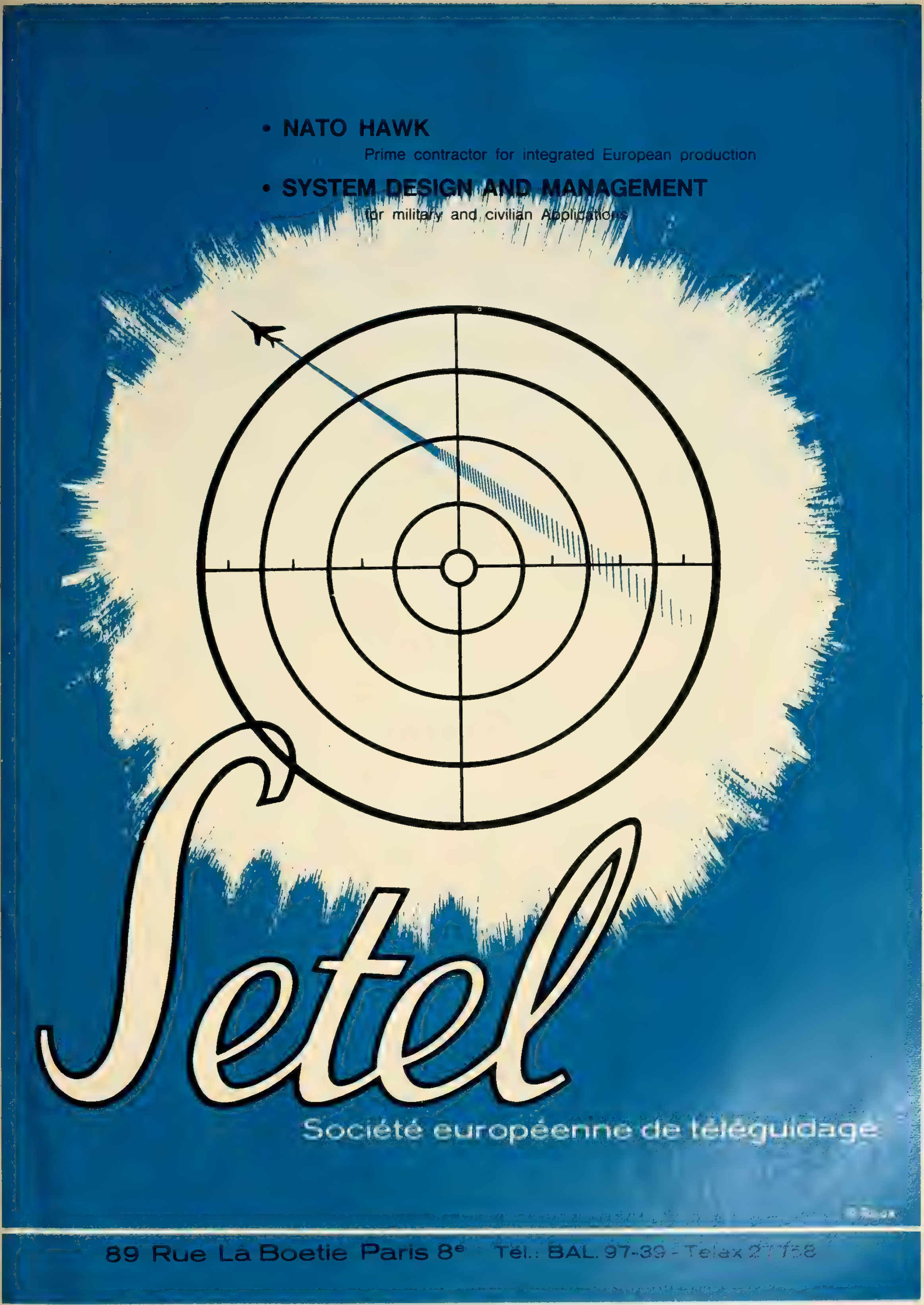
The Navy Materials Lab does similar work, but extends into other metals and also develops programs in reinforced plastics for submarines and hydrofoils, foam plastics, and polymers resistant to high-temperature fluids.

The Naval Ordnance Lab (White Oak) materials group is interested in materials and processes which enter into the construction of ordnance devices, including tactical missiles. The materials work is concentrated in chemicals, elastomers, textiles and polymers, magnetic materials, deep submergence studies and semiconductor materials.

Lab programs include polymer and reinforced plastic research dealing with property studies, mechanics of failure in reinforced plastics and glass/resin interface research. Studies into high temperature and magnetic materials involving ablation phenomena, alloy development, improvement of magnetic materials and development of nonmagnetic alloy materials are also pursued.

The Naval Ordnance Test Station (China Lake) is responsible for research and development, engineering testing and evaluation of materials used in the fabrication of rockets, missiles, underwater weapons and aircraft fire control equipment. Major studies are carried out in coatings, buoyant structural materials, heat barriers, propellants and the application of ultra-sonics to materials. Other programs cover welding, plastics and polymers, high-temperature metals and micromodules.

The major emphasis seems to be in the optimization of heat barrier materials and on the development of ad-



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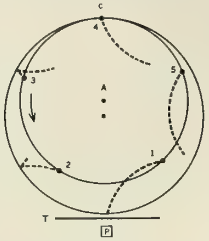

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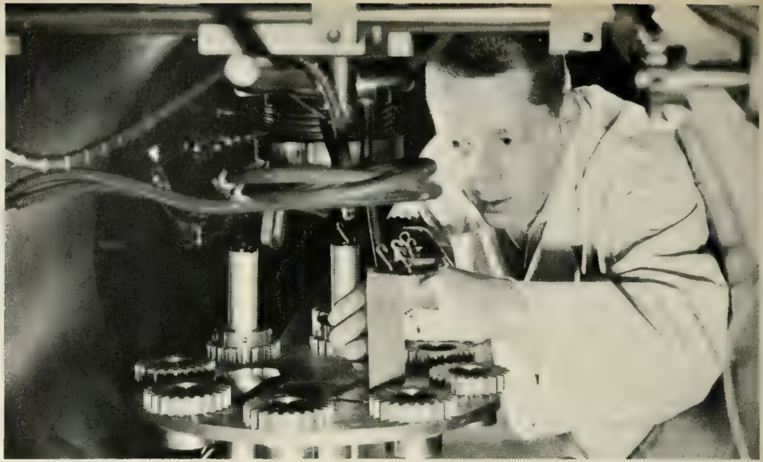


ELEVATED TEMPERATURE work is one of the largest problem areas in materials research. Here General Electric scientist examines the relationship between liquid metals and their containing structures in vacuums, and at design temperatures. Totally unknown areas such as this are now common fields of basic and applied research in materials. General Electric is also active in superconductivity work.

vanced propellants—both liquids and solids—and the application of ultrasonic energy in the deformation of structural materials.

On contract programs, the Bureau of Naval Weapons materials cognizance covers work in refractory metals, in beryllium, in vanadium alloys, in fracture mechanics and crack resistance, and in corrosion studies.

Its organics work is in ablative plastics, packaging, coatings and preservative compounds. Inorganic nonmetallic work involves ceramic coatings, radomes, properties of oxides and carbides, and the composite work covers reinforced plastics, including hollow glass fibers, the strengthening of metals through alumina whiskers, transparent plastics and high-viscosity ablating materials.

The Bureau of Ships contract effort in metallurgy is confined to steel. The electronics materials program is moving toward fuel cells but the vast section of electronics materials in BuShips is concentrated in a field outside of materials per se.

- **Air Force centralized**—With the exception of the internal work on electronic materials at the Cambridge Research Lab, the entire applied materials effort of the Air Force is conducted by the materials section of Aeronautical Systems Div. at Wright-Patterson AFB. All other work is basic and carried on by the Office of Aerospace Research, Cambridge, Aeronautical Research Lab, and Materials Central.

Air Force materials work covers six broad areas. These are: load bearing at higher temperatures, environmental protection, higher structural strength/weight, seals and sealants, energy transfer fluids and advanced electromagnetic applications.

The load bearing work includes reinforced plastics, superalloys, refractory metals and graphite bodies. Environmental protection programs are directed at heat shield research, insulation—both high-temperature and cryogenic—and damping materials.

In the search for better structural strength in lighter composites the research involves glass fibers, sandwich construction and the lighter metals such as beryllium, titanium and aluminum. Sealant work includes high molecular weight polymers and other approaches for space, high-temperature and radiation environment applications.

- **Basic research**—Including the funds the Advanced Research Projects Agency uses in specified materials programs, the identifiable materials research programs of DOD are split 46-54 between basic and applied work.

ARPA's materials budget runs to about $22 million a year and $16 million of this goes into the DOD share of the Interdisciplinary Laboratory Program (IDL) in Materials Science. This program supports a broad materials effort at a dozen major universities across the U.S. A larger group of universities shares in the ARPA Equipment Grant Program, which provides for the purchase of vitally needed equipment at institutions working under DOD research contracts.

The IDL program was first implemented in 1959 and is already bearing fruit. One of the major objectives was to increase the output of Ph.D's in the materials field by approximately 75%. A significant increase is already being observed.

The IDL program, in essence, is designed to break down within universities the interdepartmental walls, which have separated the basic physical sciences comprising the whole field of materials. The work statements in the contracts signed by the 12 universities call for theoretical and experimental studies in solid-state physics, metallurgy, chemistry, ceramics, polymer science, surface phenomenon and continuum mechanics.

The 12 institutions involved are Cornell, Northwestern, University of Pennsylvania, Massachusetts Institute of Technology, Harvard, Brown, Chicago, Stanford, University of North Carolina, University of Maryland, Purdue and Illinois.

Buildings have been constructed under the program by Cornell, Northwestern, Pennsylvania, MIT, Harvard and Stanford. ARPA does not pay for the buildings under the IDL, but employs a use-charge system—allowing a 10% per year recoupment by the institution until either the building cost is reached or the contract ends.

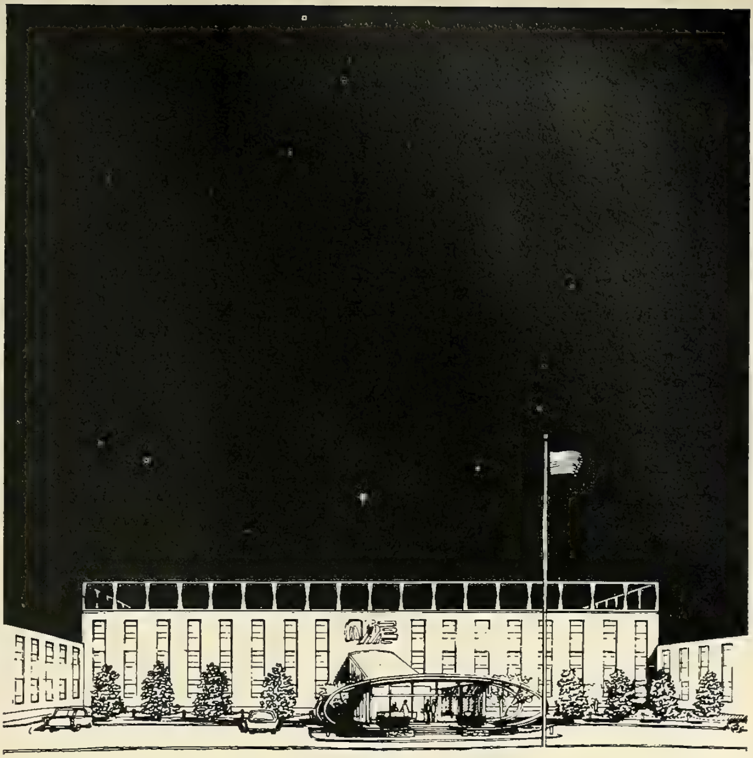
- **Long-range aspect**—The program recognizes that many of the scientific investigations undertaken will run for considerably longer than a year. The contracts are written for four years of support with an annual renewal review. The yearly examination is more consultative than directive since the materials problems under attack do not lend themselves easily to finite delineation.

The program is administered by Charles Yost, Director of Materials Science, ARPA, for the DOD. Yost feels the program has succeeded in aiding the natural development of a recognizable materials science in the U.S. The work is largely directed toward solids, with small efforts expended in liquids and gases and some in necessary engineering work. Although ARPA does little active technical directing, it does exercise complete financial control over all aspects of the program.

A point to remember is that ARPA funding represents only the DOD portion of the program. Other government agencies and the universities themselves supply funds. Counting Fiscal '64 support, ARPA has invested close to $80 million since the inception of IDL.

- **Crystal chaos**—The second major materials effort in ARPA is the Materials Preparation Program (MPP)—directed at obtaining a precisely defined material. In spite of the enormous amount of solid materials work—both basic and applied—going on in the U.S., very little emphasis has been placed on determining the nature of a solid before working with it.

A prime example is the present electronics industry—an enormous segment of the economy based on the ability of a crystal grower to introduce crystal



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imperfections in a controlled manner. The only successful firms in that area now are those that made a science out of crystal growing instead of relegating it to a service function.

The word "solids" in the MPP sense covers everything crystalline and is not specifically taken to be exclusively concerned with electronics—as in "solid-state devices".

The DOD effort to introduce some order into this area centers in the Materials Preparation Program (MPP). The fundamental science on which all solids research depends stems from the availability of well-characterized, precisely defined crystals. Secondly, the genesis of all devices making use of solids is traceable to the ability to grow crystals in a controlled manner.

The ARPA program is the only such effort and serves as the focal point of the materials community.

MPP consists of four areas:

—Crystal growth techniques and the relation between growth processes and physical and chemical properties.

—The acquisition of precisely defined crystals.

—Precise characterization and analysis of crystals.

—Information dissemination.

Seven specific material types were listed as most important—alkali halides, electronically active materials, metals, superconductors, rare-earth metals, nonmetals and laser materials.

Alkali halides were selected as the lead group to be used as a control of techniques and characterization studies since this is the best defined crystallographic series. The Naval Research Lab is handling this work.

Initial projects into electronically active materials are being funded at the RCA Labs in Princeton, N.J. The metals work is designed to produce and understand high purity metals with an ultimate aim of developing higher temperature and higher strength alloys and compounds. Materials Research Corp. is one firm in this area.

Superconductors—especially those capable of operation above 3-4° K—are being investigated at RCA. Westinghouse will be studying rare earths and General Electric will be covering nonmetals.

ARPA's laser work is more a case of observing than contracting, though the agency was instrumental in developing the field in the first place.

• **Numerous techniques**—There are a variety of crystal-growing methods. A partial list would include the following major approaches.

—Crystal growing methods independent of chemical reaction. These include methods based on crystallization from a pure melt such as the Bridgeman-Stockbarger method, the Czochralski-Kyropolous method, the Boule or flame fusion method, the ARC furnace method, the horizontal zone method, the vertical floating zone method, the top molten slug method and the molten pool method.

The other major sub-area is growth from solution—isothermal growth, non-isothermal solution growth, hydrothermal growth and the growth of crystals from a molten flux. There is also strain recrystallization and recrystallization in a magnetic field.

—Crystal growing methods involving a chemical reaction. This area includes crystal growth from vapor phase, during solid-state reactions, from solutions of the ingredient and by electrodeposition.

This partial list of methods points out the large variety that exists and that the physical and chemical properties of a crystal are completely dependent on the growth method.

MPP contracts in this area are with Pennsylvania State University (the only educational institute in the program), Materials Research Corp. and TYCO Laboratories, Inc.

ARPA is trying to interest the National Bureau of Standards in estab-

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lishing itself as the national focal point in the characterization and analysis aspect of the MPP. The Oak Ridge National Lab has established a Research Materials Information Center for the purpose of collecting and disseminating information on kinds of crystals available and their properties.

The program is dynamic and the current gap is in the metals and nonmetals areas. ARPA is aware that some of the materials discovered or prepared in the program may need additional funding for development toward applications. The present attitude is to await these developments and treat each on its merits rather than by setting up a specific program.

- **Coupling movement**—Both the IDL and MPP efforts are idea-producing areas and the DOD is, by definition, pragmatic. ARPA is shifting from passive to active in these programs. The current thinking is directed toward getting the DOD materials problems into the mill—and to do this without disturbing the original intent behind the programs. Yost believes a coupling is possible.

Technology proceeds in industry while fundamental work is concentrated in universities. Industry cannot afford to take the risks inherent in long range basic research while there is an inherent ability within a university to do so. The problem is to get the fundamental producer into bed with the fundamental user.

One way would be to hand the problem over to a not-for-profit organization located in the geographical area and allow it to serve as a coupling point.

Another method is to give industry the type of support inherent in the IDL program, but with slightly greater direction towards specific DOD materials problems. A mixing of IDL personnel and industry researchers is already going on at RCA in a modest project. The desired result is that each will understand the other's problems—while working on a DOD materials project.

There are two other approaches being contemplated. One is to have selected personnel from DOD labs work in university labs for several-month periods. This method is yet an idea but the rationale is again to penetrate the university work with some knowledge of DOD problems.

A second method is to hold carefully planned meetings between university personnel and DOD researchers. The problem here is to achieve active participation by all participants in a discussion of applications rather than by lecturing to each other.

The meeting method is not a shotgun approach. The fundamental work represented by the university will be related to the applied work represented by the DOD lab personnel.

The mixture of talent and problems initiated with the RCA contract is not a profit-type contract, and RCA will be supporting its own personnel. The contract carries the standard patents and proprietary information clauses, but the whole project is something of an experiment.

As the careful cultivation of the materials field by ARPA continues, there may be many such small efforts. And while ARPA will respect the proprietary rights of a firm, the feeling is that the agency should not be delayed by the red tape of a patent review. A mutual trust must be developed in this area, with ARPA being informed of developments as the work proceeds. In return for this, the agency must be discreet in handling the information, since industrial firms will be extremely mindful of commercial applications in the future.

If this mutual trust is created and the arrangement functions well, then the pattern for future DOD research contracts may be set—at least in the basic areas where technology meets lab and theory. ■

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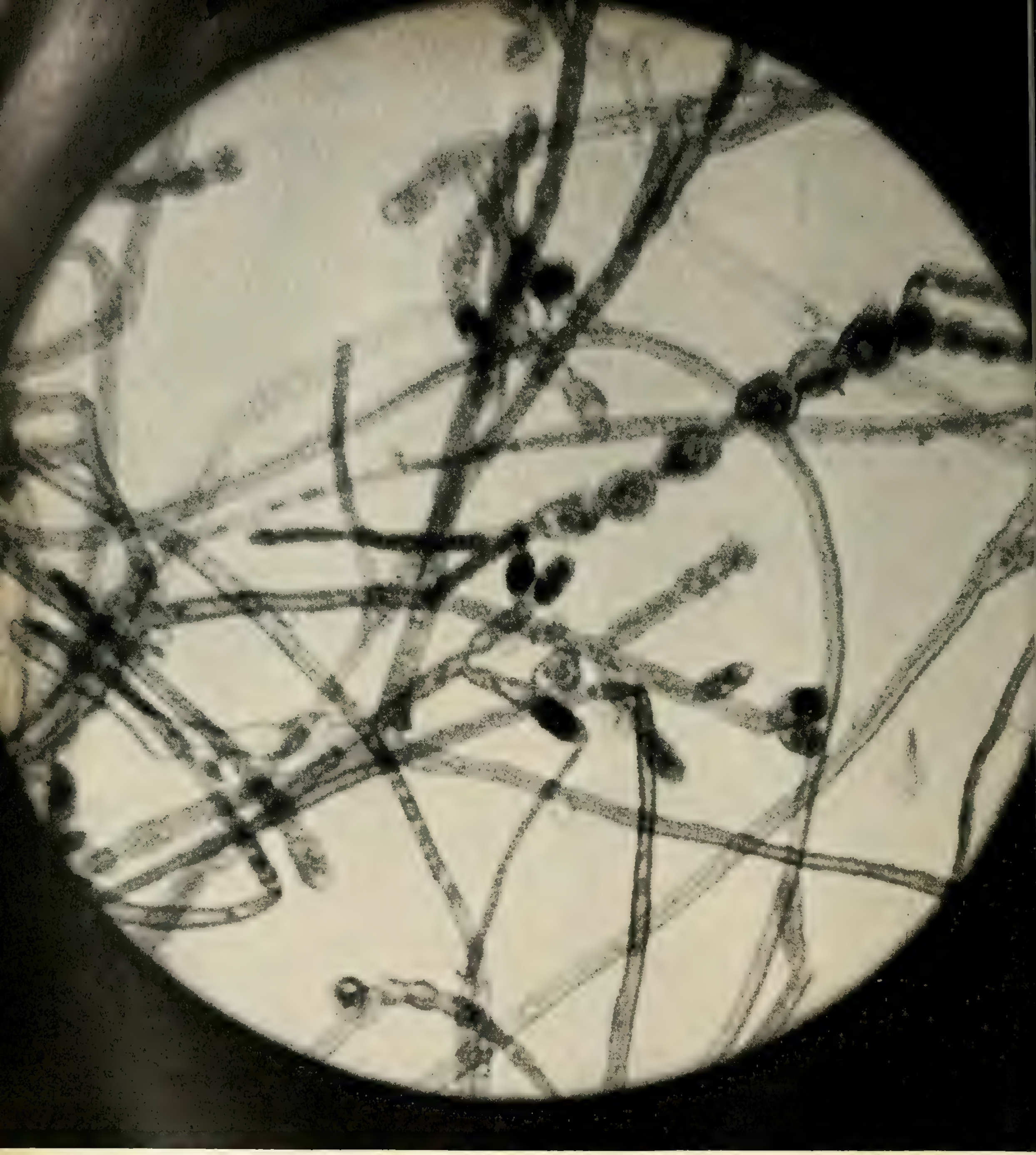

Bugs in the fuel tank

For some time now, jet-powered airplanes have been plagued with fuel corrosion damage. The culprit? *Bugs!* Bacteria, algae, fungi, yeast growths. These microscopic beasts not only can stay alive in the fuel—they eat it! And they have the rubbery tank lining material for dessert!

Result: Microbial sludge builds up. Fuel probes and filters are plugged. Skin and structures are eaten through, causing leaks and weak spots.

The United States Air Force and the Petroleum Industry have developed additives that have reduced the hazard drastically. And Lockheed-Georgia researchers are conducting a program to determine the basic mechanisms of the microbial corrosion process. Lockheed's work, along with other industrial and military programs, promises to eliminate the problem in the near future.

Another example of the advanced aerospace research now going on at **Lockheed-Georgia Company**

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Propulsion Know-How Considered Equal to Needs of Future Weapons

But a number of advanced programs are being readied in case it is decided to proceed with development; three liquid concepts are being pursued; Titan III and large solids are major efforts

A SET OF liquid and solid propulsion systems—ranging from large boosters in both categories to upper stage and space powerplants—are moving toward the development starting line in the prevalent Director of Defense Research and Engineering management concept.

All are in the Advanced Development cycle—which means they have no specific mission, but are being guided toward a state of readiness should a development decision be made.

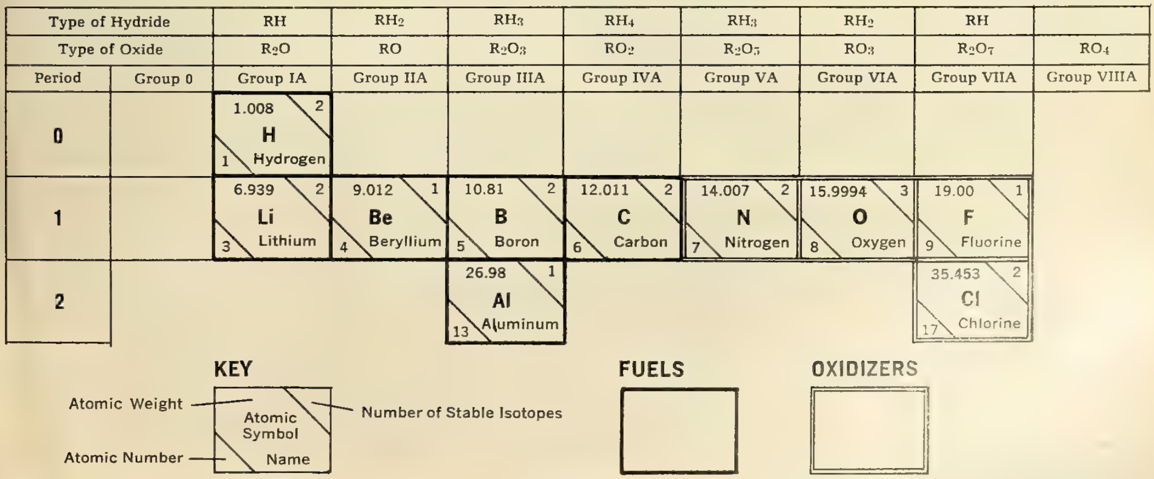
It also means the programs may never reach development as technology proceeds and mission studies change. The idea is to develop these various systems to the point where a rapid phasing into development is possible.

Propulsion, in general, is one of the less troublesome areas on the DDR&E agenda. There are no crash efforts, and the broad technology created since the early days of ICBM development is considered adequate to meet any demands posed by foreseeable weapons systems.

There is more activity in propulsion systems designed to support manned military operations in space, but it is not tied to any definite mission at the moment.

- **Specific systems**—There are three recognizable liquid propulsion unit programs moving through the Advanced Development category within DDR&E. These include a high-energy upper stage, a space-maneuverable system and an advanced liquid booster engine.

The high-energy upper-stage work is coordinated closely with NASA concepts in the same area and the nature



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BASIC RESEARCH into advanced propulsion has all but exhausted the fuels side of the periodic table. Oxidizing elements are still a major research problem. This work will be entirely service-handled by 1965, with ARPA phasing out.

of the investigation is classified. The engines might involve hydrogen and fluorine, and resemble similar work funded by NASA involving the conversion of the RL-10 to a fluorine unit.

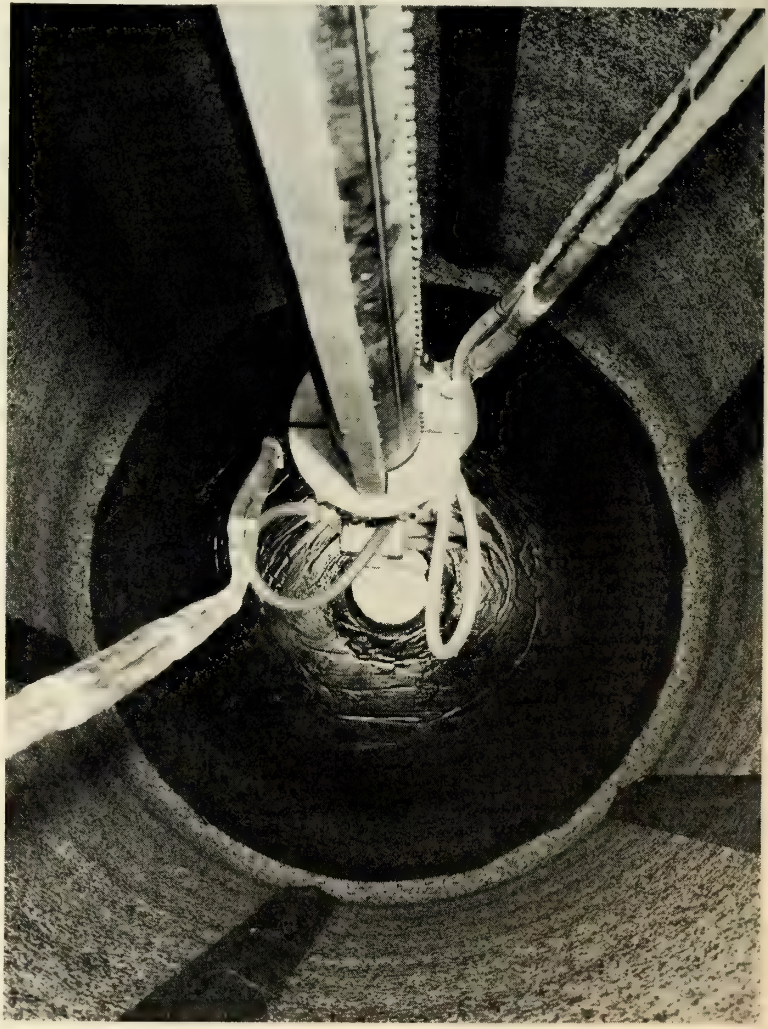
The maneuverable upper stage work is probably directed toward the propulsion problems associated with inspection satellites and other military satellites demanding in-space propulsion. It is new in Fiscal 1965 and directed toward component development.

The advanced liquid engine concept is classified, but it is supposed to have an operational performance greater than that of the NASA-funded M-1, which will reach thrusts up to 1.5-million lbs. The M-1 is designed for cryogenic propellants while the new DOD engine will use storable fuels and oxidizers.

The large liquid engine is funded by the Air Force, as are all the other liquid units, and details are classified. But the scanty facts revealed to date fit a new engine development program announced recently by Aerojet-General.

In this project, the company disclosed activity on a new high-energy liquid rocket engine capable of single-stage, earth-to-orbit missions. The engine is being designed in two versions—one storable and the other cryogenic. The cryogenic version is not receiving the funding attention devoted to its storable cousin.

The Aerojet project is admittedly not based on any high-energy propellant breakthrough, but on an engineering hardware approach. However, the



HEAD OF a case liner machine moves into position within a Minuteman first stage. The dark strips are lightweight slivers positioned opposite the grain star points. Propellant is not completely used in this area, and the slivers are a weight-saving innovation.

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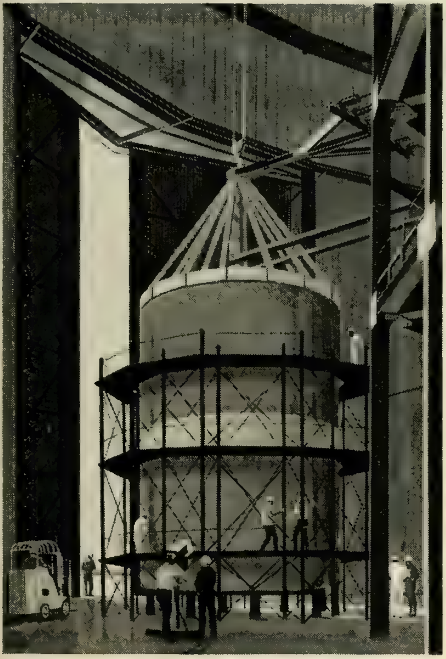

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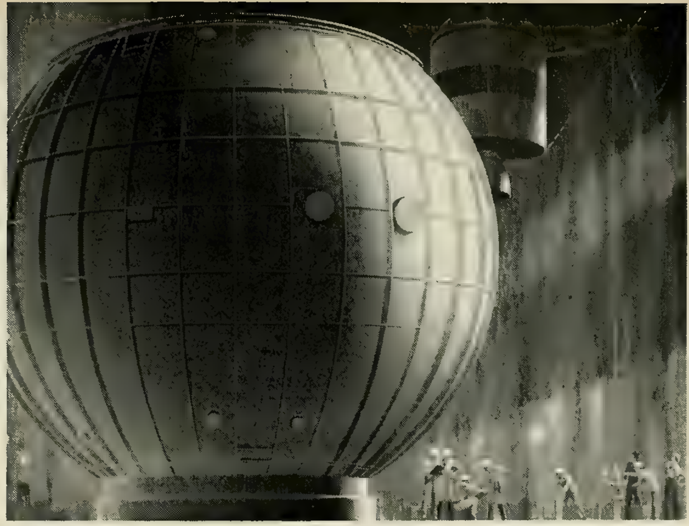

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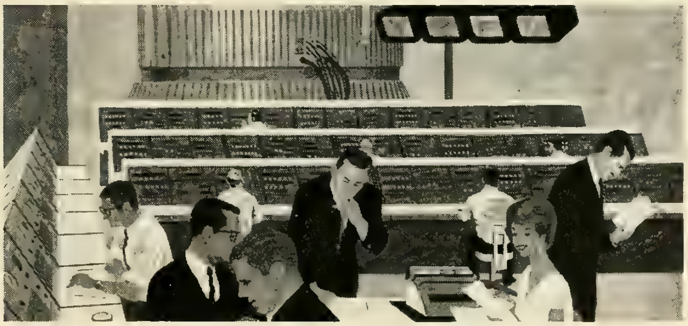

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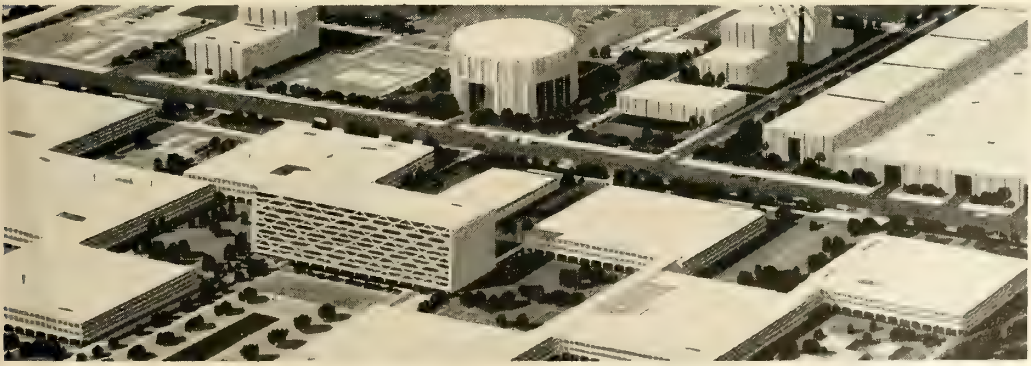

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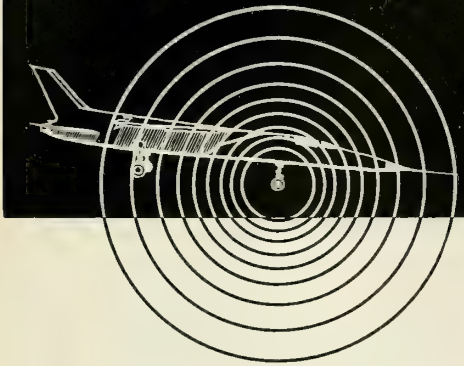

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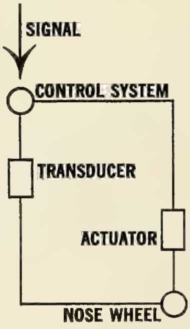

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unit is said to be capable of using high-energy propellants.

Aerojet spokesmen say the unit is designed along a modular concept and that the hardware development permits the high performance with a smaller overall configuration. Thus, in operational use it would most likely be clustered.

One aspect is known—the engine has a higher chamber pressure than current booster units. This apparently means means the chamber pressure is anywhere from 1,000 psi—the current level—to about 10,000 psi, the theoretical maximum with presently contemplated fuels.

In conventional liquid engine cycles, 6,000 psi is a more realistic chamber pressure target. This is because the unit must be pump-fed and the energy required to drive such pumps goes up at an even steeper rate than the chamber pressure. Therefore, some sort of compromise is necessary.

There are also difficult cooling prob-

CAST Nike-Hercules motor moves to curing ovens at Thiokol's Longhorn, Tex., facility. Military tends to prefer solids because of handling, storability and reliability factors.

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On January 29, NASA's Saturn SA-5 lifted off from the pad at the John F. Kennedy Space Center carrying the first live S-IV second stage and the heaviest payload ever orbited—more than 37,000 pounds.

It thus established beyond a doubt the dependability of Saturn I, and its fitness for the key role it will play in our nation's space exploration program.

The role of the upcoming Saturn IB in the NASA Apollo program will be to earth orbit manned Apollo spacecraft vehicles for tests of the rendezvous and docking methods to be used in later manned lunar landing flights.

It is also the logical vehicle for all programs where relief from the present weight and space restrictions on payload are desired.

In fulfilling its role in the expanding national space program CHRYSLER Corporation SPACE Division—prime contractor to NASA for the first stage of the Saturn I and IB vehicles—has a continuing need for creative, experienced engineers and scientists at all levels and in many disciplines.

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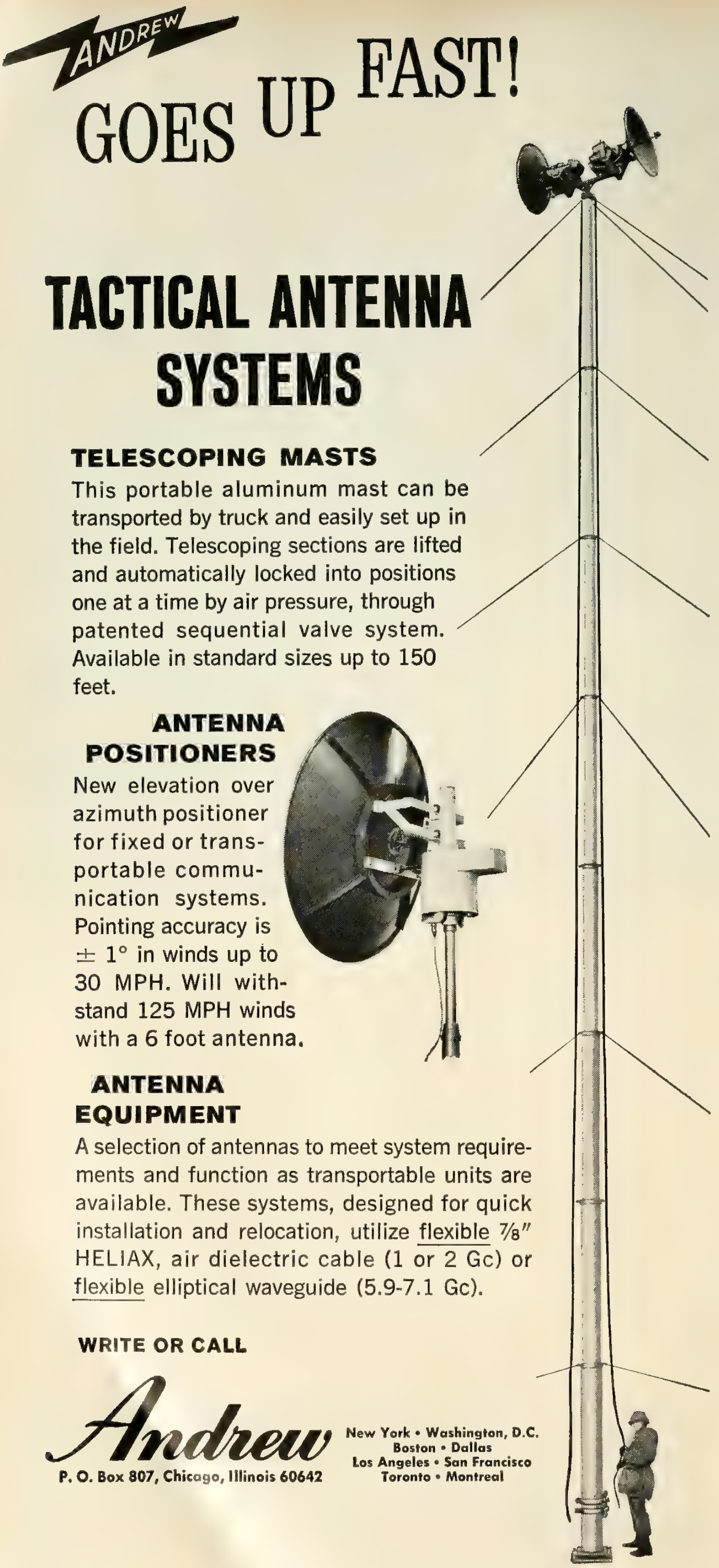

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lems associated with higher chamber pressures, and since the engine is using storables, there is little in the way of heat-removal capacity when compared to that offered by cryogenic propellants. But there are other methods.

The whole area of liquid rocket engine development is slated for $10 million in requested funds. Testing new concepts in liquid rocket component technology has $6.5 million, and $2.5 million is allocated to define the design criteria and performance parameters for a high-energy upper stage. The rest of the requested money will provide for ground testing of advanced propulsion concepts applicable to the development of a space-maneuvering propulsion system.

- **Solids work**—The largest single item in the vehicle, engine and components area funded by DOD is the Air Force's *Titan III* program. The vehicle, consisting of two 120-in.-dia. strap-on solid boosters tied to a *Titan II*, storable-fueled, two stage core, is expected to be a many-mission workhorse.

The *Titan III* will be used to launch payloads large enough to explore the many unknowns in manned space work —including a manned orbiting lab.

At the moment, the vehicle is justified primarily as a cost-savings program and will remain an active project as long as it meets this criterion. Indications are that it will.

The next largest propulsion item within the cognizance of DDR&E is the Solid Propellant Motor Development program. About $12 million is programmed in fiscal 1965 for the 156-in. section of this effort. NASA is assuming financial responsibility for the 260-in. section since foreseeable military requirements will be fully met with the smaller-diameter motor.

DOD is managing both programs on behalf of both itself and NASA.

There is little doubt in official circles that the large solid program will successfully demonstrate the feasibility of such scale-up. Previous similar efforts in solid technology have met with marked success—specifically the *Minuteman* program. The *Titan III* 120-in. diameter boosters (propellant load in each of the five segments equals that in 1.2 *Minutemen*) have been fired without any propellant hitches.

The classified programs directed toward development of high-acceleration solid propellants in the Class 2 explosive-transport category of the Interstate Commerce Commission are nearing completion. This work is a back-up to the high-energy double base propellant effort at Hercules Powder in the *Sprint* program. This propellant is in the ICC Class 9 category—a much more sensitive mixture.

The long range programs funded in

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New space power—the hybrid

Better than three years ago, UTC recognized the potential of the hybrid rocket motor and launched a pioneering, company sponsored program to make this power available.

The advantages to be gained: simplicity and reliability of a solid, controllability of a liquid, low-cost, no explosive hazard, higher specific impulse than a solid, higher density than a liquid, wider propellant selections, thrust modulation, stop-start capability—the characteristics of an ideal propulsion system.

Past history of hybrid developments, however, divulged some particularly knotty problems such as poor combustion efficiency, very low burning rates and non-uniform burning of the fuel.

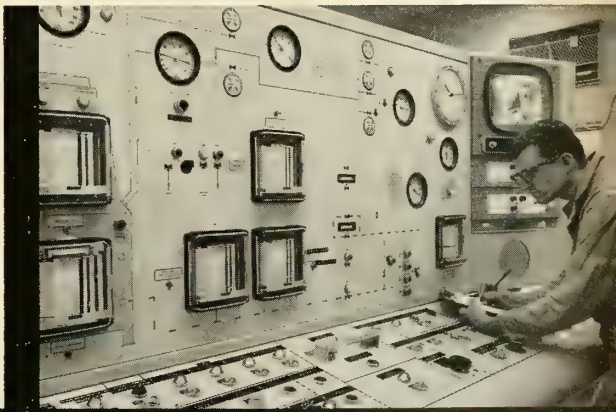
Because of its rapid progress in solving these problems during those early years, UTC gained the support of the Advanced Research Projects Agency, the Air Force and the Naval Bureau of Weapons, and reawakened the interest of the entire propulsion industry.

Primary reason for the unequaled results obtained by UTC in its hybrid rocket program is that company scientists made as their first objective the study of what happens inside such an engine, i.e., the basic phenomena of hybrid combustion.

Because of this advanced knowledge, UTC is now developing a hybrid propulsion system with the highest performance of any in the field employing readily available chemicals; has in over 7,800 test firings of hybrid rocket motors achieved reliability in excess of 99.9%; demonstrated in numerous test firings throttling and stop-start capabilities; designed hybrid rocket configurations capable of performing existing space missions at a cost of 30-40% less than other propulsion systems in use today, and has produced the only hybrid rocket motor that can be test fired publicly because of its safety features.

Thus the initial establishment of a sound scientific foundation by UTC, followed by an aggressive development program, has brought the hybrid rocket into the family of practical, predictable and reliable space propulsion systems.

Scientists and engineers at UTC welcome sophisticated propulsion challenges such as this—and welcome others with quiet competence and inquiring minds who seek such challenges.



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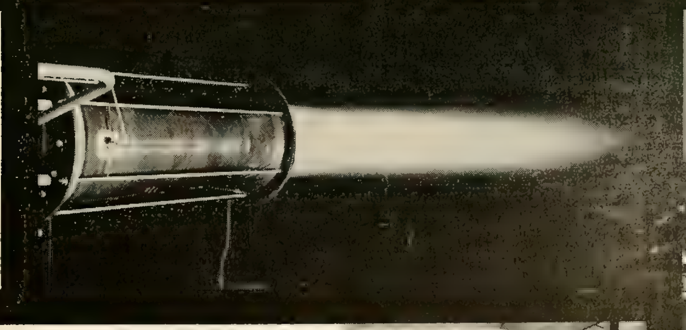
capability over
the full spectrum



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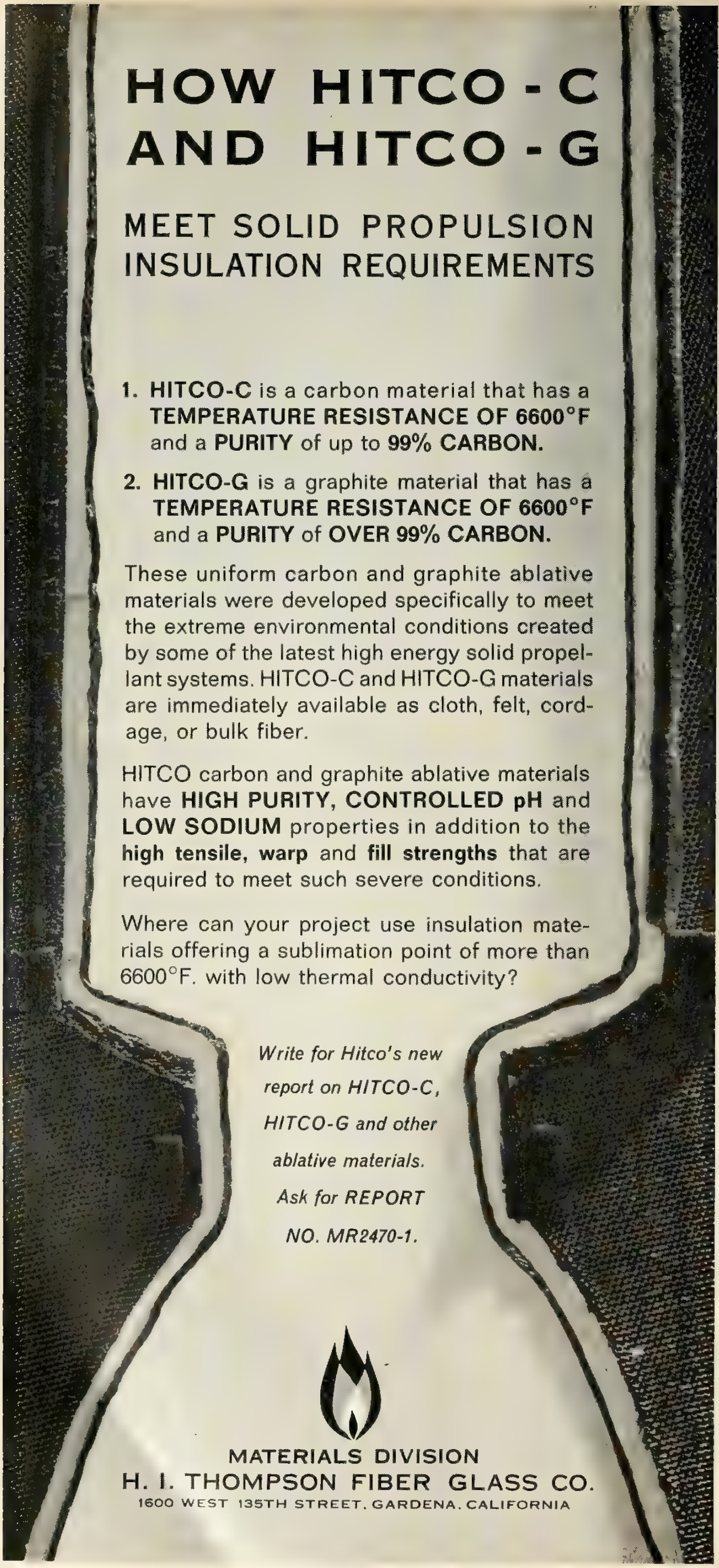

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the *HIBEX* category are directed toward development of second-generation high-acceleration solids.

• **Nature of propellants**—The chemical propellant portion of the propulsion picture is centered in the Assistant Director (Chemical Technology) under the Office of the Deputy Director for Research and Technology. Dr. Jack T. Thurston currently holds the position.

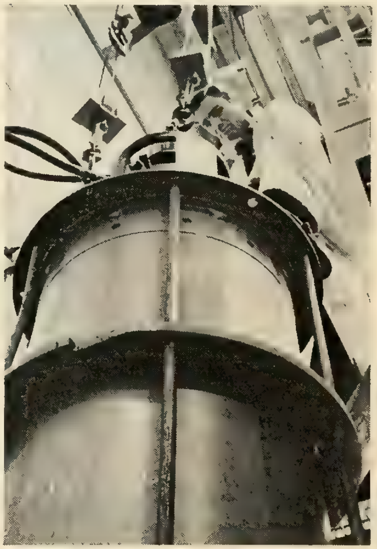
Thurston has been mainly concerned with problems of chemical warfare, but propellant chemistry is receiving more and more attention.

Consistent with the prime purpose of DDR&E, Thurston keeps close tabs on propulsion research through the three services, with emphasis on intelligent coordination of effort.

Thurston's office does not get very far into hardware, but stays with the chemical end of propulsion research and technology. The military is not too enthusiastic about cryogenic propellants, so the vast majority of research toward new and improved chemical systems concentrates more on solids, storables and hybrids.

The main problem is to keep the services from short-changing the research area. There is a tendency to move into hardware. The method of control is to withhold segments of allocated funding to the various branches to hold them in line.

Since the services will assume all of the high-energy chemical propellant work now within the jurisdiction of the Advanced Research Projects Agency by 1965, the Assistant Director for Chemi-



MANDREL is eased out of Nike-Hercules sustainer motor at Thiokol-Longhorn. The contractor-operated Army plant recently shipped its 150,000th solid motor.

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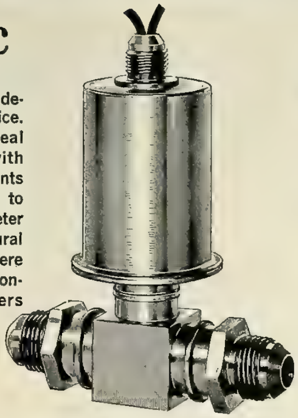
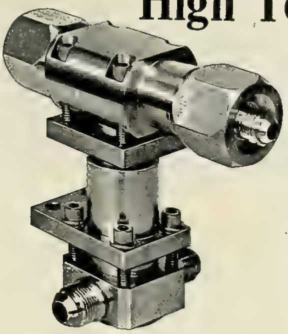


Series 446 Specifically designed for liquid gas service. A gate type floating-seal valve. Direct acting with straight line flow. All joints are inert heli-arc welded to guarantee mass spectrometer leak tightness and structural soundness in the most severe applications. All steel construction. No elastomers used — anywhere.

Specifications:

Temperature range	—452°F to +600°F
Max. operating pressure	up to 2300 psi
Leakage	liquid, ½ cc/hr. maximum
Voltage	18-30 V. DC
Current	1.3 amps max. @ 30 V. DC 70°F
Dielectric	1000 volts RMS minimum

High Temperature



Series 420 for control of metal vapors and molten metals . . . typical examples are liquid potassium, lithium, cesium, sodium and others. It is a floating, shear-seal type with straight-through flow. Valve may be activated directly or remotely; pneumatically, electrically or manually. Variable orifice feature. This unique design has a **proven** record of reliability in actual usage.

Specifications:

Temperature	up to 2200°F
Max. operating pressure	500 psi. Higher pressures at lower temperatures
Leakage	external — zero internal — 0.01% rated flow max. Tighter control is possible depending on application.
Ports	available from ¼" to 1" O.D. tubing

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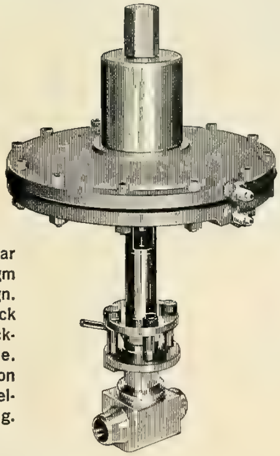


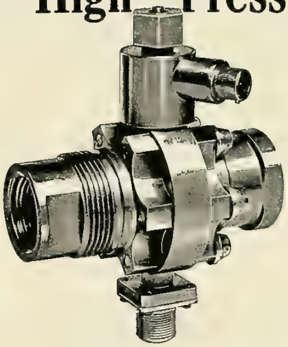
Series 427 Excellent for high temperature, vacuum and/or corrosive service. This valve series is a bellows seal (diaphragm type) pneumatically operated 2-way shut-off design. Its major usage has been in nuclear applications. The diaphragm is a spring-loaded design. Construction contains back seating and secondary packing. Plug is replaceable. Hexagon anti-torque section prevents damage to the bellows from possible twisting.

Specifications:

Temperature	—423°F to 1500°F
Leakage	Internal (seat) Liquid: 1/10 cc/hr. Gas: 1 cc/hr. per 1/10" seat diameter With soft seal leakage is bubble-tight.
End connections	¼" to 1"NPT; socket weld or butt weld

Series 427 is but one of many Valcor series suitable for nuclear service.

High Pressure/Flow



Series 387 Designed for high-pressure, high-flow pneumatic service over a temperature range of −65°F to +500°F. Coaxial type. We believe this valve series offers the lowest pressure drop of any poppet valve. The unusual bulkhead mount allows the valve to function through vibration up to 20 G and shock loads up to 40 G. The unique valve seat enables the unit to withstand the erosive effect encountered in high pressure, high flow pneumatic systems.

Specifications:

Pressure	100 to 5000 psi
Flow	C_v of 6.9 with —12 port
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Leakage	4 cc/hr. maximum
Voltage	18-30 V. DC
Current	1.0 amps maximum @ 30 V. DC 70°F
Dielectric	1000 volts RMS minimum

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cal Technology will have an even larger problem. ARPA funds this work through the services so the money is specifically earmarked. When the services gain complete control, there will not be any "sacred" funding in the area.

- **Chemical controversy**—The decision by DDR&E Director Dr. Harold Brown to phase chemical propellant research out of the Advanced Research Projects Agency and into the different services has caused some consternation in the chemical industry.

The actual work involved is highly advanced and consists of complex research into the nature of propellant chemistry. Programs cover fuel and oxidizer synthesis, thermochemistry, combustion research and combustion instability and high-temperature nozzles. By far the largest effort has been in synthesis.

The ARPA chemistry program had three main objectives—to commence and maintain a concerted effort in chemical research, to directly coordinate all propellant chemistry work and to get the chemical industry involved.

A strong movement into the chemistry of propellants has been achieved, and the greater part of the chemical industry has been using ARPA as their focal point in DOD. ARPA's technical direction speaks for itself (through financial control, since the only real authority in DDR&E is control of the dollar).

The Periodic Table has been practically exhausted with respect to possible fuel combinations, but many critical problems remain with the oxidizer elements.

There is some feeling among industry chemists that the services, because of their understandably parochial outlooks, will not provide the type and kind of direction that has been available in ARPA.

Several industry experts have termed the move a step backward—as it might well be, since the upper level of executive ability within DDR&E will then lack adequate representation in basic chemical research.

With the possible exception of pharmaceuticals, the chemical industry has always been the one major sector of the business community with a long standing and demonstrated faith in basic research.

The Defense Department has had to drag all others into adopting this viewpoint over the years.

But this devotion to research has often resulted in a deliberate avoidance of federal interference. Most of the DOD-sponsored chemical research work has gone to areas outside of the classical chemistry industry. This has resulted in the creation of a powerful and advanced industrial complex foreign to the historical chemical community.

The federal funding is thus altering the shape of the chemical industry and also siphoning off chemists from what once was their natural area of industrial employment. One west coast missile/space firm employs more chemists west of the Mississippi than any member of the chemical industry in the same geographical area.

While the past attitude of the chemical industry as a whole may somewhat weaken their argument against the shift of advanced or high-energy propulsion research from ARPA to the services, there is some justification in the claim of a loss of direction.

On the other hand, there is also the basic premise behind all of ARPA's actions—that its projects are only to be carried to the point of military competence and then shifted to the services.

The decision has been made, and by 1965 there will be no high-energy chemical work in ARPA. The chemical industry is left with the job of finding one of its technically competent executives willing to accept a position with DDR&E, since the current Assistant Director for Chemistry is scheduled to leave DOD in the near future. ■

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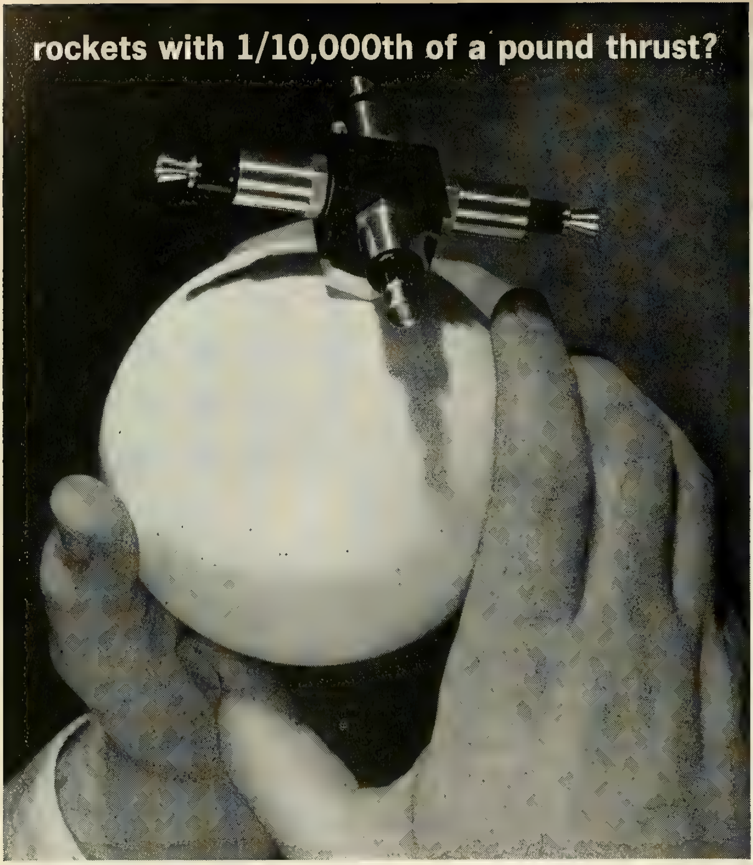

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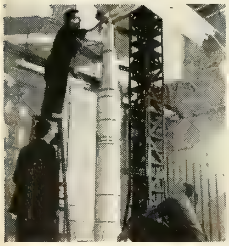

Apollo payload is placed atop a scale model of the Saturn V booster preparatory to wind tunnel tests.

—names in the news—

Ronald Sneddon: Named chief systems engineer of the LTV Ling Electronics Div. of Ling-Temco-Vought, Inc., Anaheim, Calif.

John R. Clark, Jr.: Appointed Washington, D.C. representative for Textron's Bell Aerosystems Co.

Jack T. Gentry: Appointed chief executive officer of the Winchester Electronics Div. of Litton Industries, Norwalk, Conn.

Anthony M. Johnson, Jr.: Named marketing manager of Korad Corp., Santa Monica, Calif.

Dr. Walter C. Williams: Elected a vice president of Aerospace Corp. and named general manager of its Manned Systems Div., El Segundo, Calif.

Sam C. Dominey: Appointed director of the *Apollo* propellant gaging system program at Giannini Controls Corp.'s Control/Nucleonics Div., Duarte, Calif.

Dr. Wilbert A. Taebel: Joined the Research & Development Div. of National Beryllia Corp., Haskell, N.J.

Norman L. Harvey: Appointed manager of the solid-state products unit of Varian Associates, Beverly, Mass.

Joel E. Tumarkin: Joined Operations Research, Inc., Silver Spring, Md., as a member of the associate staff, Management Systems Div.

Andrew C. Marshall: Appointed vice president-applications engineering of Hexcel Products, Inc., Berkeley, Calif.

Reynolds Marchant: Appointed government representative for the Nuclear Products Dept. of the 3M Co., St. Paul, Minn.

Richard F. Trader: Joined the AeroChem Research Laboratories, Inc., Princeton, N.J., as manager-government contracts.

R. E. Reilly: Promoted to vice president-finance of Ilikon Corp., Natick, Mass.

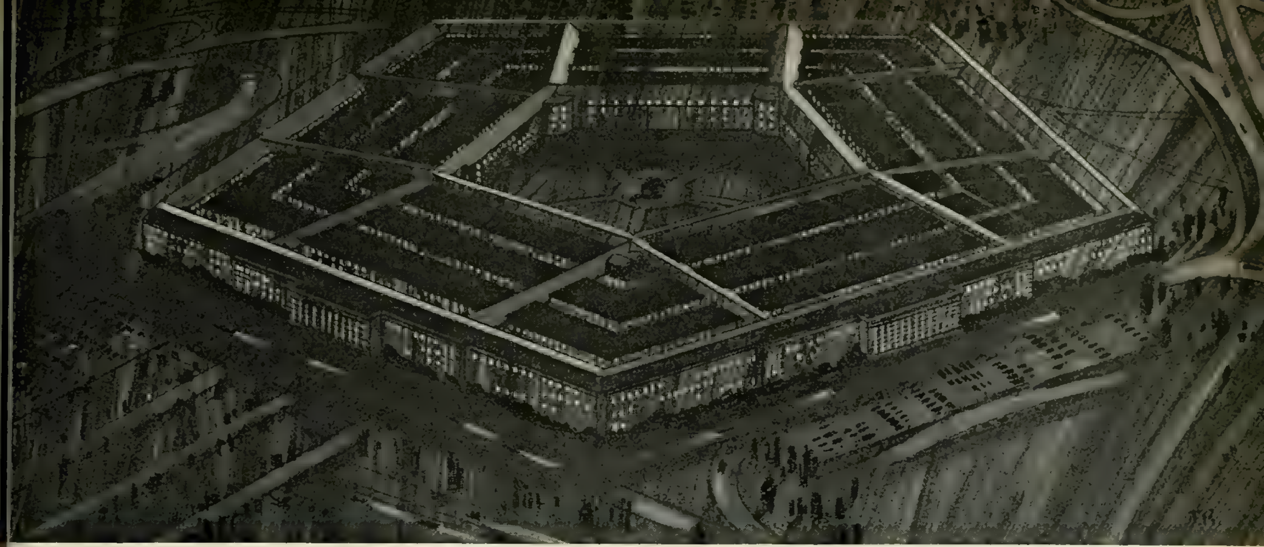
Albert J. Dinicola: Appointed general manager of Marshall Industries' G. S Marshall Co. Div., San Marino, Calif.

Joseph Philipson: Joined Haveg Reinhold, Inc., Santa Fe Springs, Calif., as a consulting chemist.

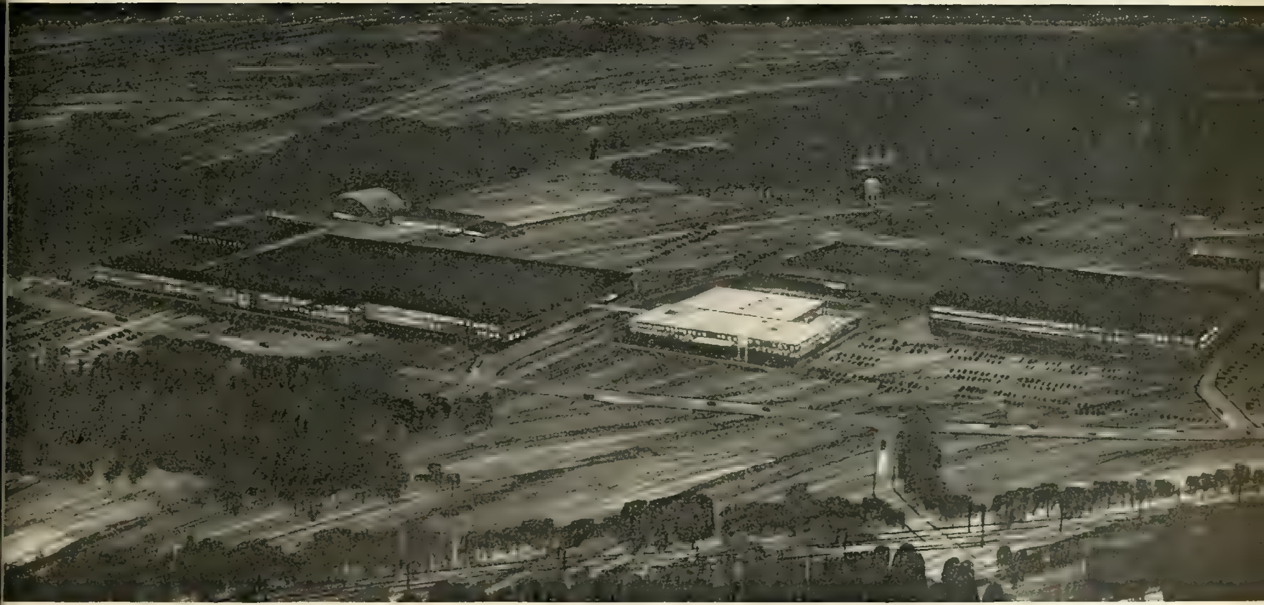
Werner Escher: Named public relations representative for Atlantic Research Corp., Missile Systems Div., Duarte, Calif.

Richard W. Harbison: Appointed president of Astek Instrument Corp., Armonk, N.Y.

Owen J. Baggett: Appointed manager of the Western Regional liaison officer of Litton Systems, Beverly Hills, Calif.



Defense Center



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Earl R. Hinz: Named director, airborne systems, mobile systems directorate at the San Bernardino, Calif., operations of the Aerospace Corp.

Maj. Gen. Moody R. Tidwell, Jr. (USAF Ret.): Appointed vice president of Malaker Laboratories, Inc., High Bridge, N.J., to serve in the Washington, D.C. area.

Vance J. Carpenter: Appointed head of the Optical Systems Dept. of Bausch & Lomb, Inc., Rochester, N.Y.

Dr. Donald R. Allen: Appointed senior staff engineer and technical assistant to the manager of missile engineering for Beech Aircraft Corp., Wichita, Kan.

Stanley J. Golembiewski: Joined International Resistance Co.'s Instrumentation and Systems Div., Philadelphia, as manager of logic systems.

Michael W. Pulscak: Joined Operations Research, Inc., Silver Spring, Md., as an associate management engineer in the Management Systems Div.

Edward Hoover: Appointed director of engineering at Correlated Data Systems Corp., Glendale, Calif.

Robert C. McCray: Elected president and treasurer of Worcester Valve Co., Inc., Worcester, Mass.

William T. Rush: Appointed industry advertising and sales promotion manager of Westinghouse Electric Corp., Pittsburgh.

Fred W. O'Green: Promoted to president of the Guidance and Control Systems division of Litton Industries, Beverly Hills.

Edwin F. Carey, Jr.: Appointed manager of international requirements for General Dynamics/Electronics, San Diego.

John Severance: Named technical news manager of Raytheon Co.'s public relations department, Lexington, Mass.

John P. Delaney: Appointed manager-market planning for Federal Electric Corp., Paramus, N.J.

John F. Antoniazzi: Named assistant division general manager of The Machlett Laboratories, Inc., Springdale, Conn.

Charles F. Cooper: Appointed manager of marketing for Kaiser Steel Corp., Oakland, Calif.

Robert C. Smith: Appointed patent attorney for the Bendix-Pacific Div. of Bendix Corp., North Hollywood.

Lee W. Topham: Joined the staff of Wiancko Engineering, Pasadena, Calif., as assistant to the general manager.

Raymond A. Ballweg, Jr.: Named corporate director-data systems engineering for Fairchild Stratos Corp., Rockville, Md.

William D. Summers: Appointed Los Angeles district sales manager for TRW

Capacitor Div. of Thompson Ramo Wooldridge.

Harold D. Shelley: Named sales engineer for telemetry and surveillance equipment at Vitro Electronics, Silver Spring, Md.

Warren G. Knieriem: Appointed corporate director for quality control and reliability for Garrett AiResearch, Los Angeles.

Dr. Norman E. Friedmann: Promoted to president of ITT Data and Information Systems Div., New York City.

Dr. Harold A. Rosen: Appointed manager of the communications satellite laboratory of Hughes Aircraft Co., Culver City, Calif.

Dr. Martin H. Bloom: Named head of the department of aerospace engineering and applied mechanics at the Polytechnic Institute of Brooklyn, N.Y.

M. E. Forgey: Appointed product sales manager-electronic systems for the Los Angeles Electronics Div. of Electronic Specialty Co.

John A. Roberts: Appointed director of marketing for the Magnetic Core Corp., Newburgh, N.Y.

James H. Raport: Appointed corporate vice president of International Rectifier Corp., El Segundo, Calif.

Leo W. Ollila: Appointed general manager for the eastern division of Wyman-Gordon Co., Worcester, Mass.

Donald H. Pile: Named Air Force requirements engineer for sensor products at General Dynamics/Electronics, San Diego.

John M. Malone: Elected vice president-sales of Tung-Sol Electric, Inc., Newark, N.J.

W. L. Duval: Named director of the Douglas Missile and Space Systems Div.'s Sacramento, Calif., Test Center.

Robert A. Huff: Named manager of product publicity for Electronic Associates, Inc., Long Branch, N.J.

Dr. Milton G. Holmen: Named director of personnel for System Development Corp., Santa Monica, Calif.

John M. Meyer, Jr.: Named manager of Washington operations for Aerojet-General Nucleonics, Washington, D.C.

Robert L. Wehrli: Elected executive vice president and director of Robertshaw Controls Co., Richmond, Va.

J. Frederick Medford: Appointed chief reliability engineer for aerospace systems engineering at Douglas Missile & Space Systems Div., Santa Monica, Calif.

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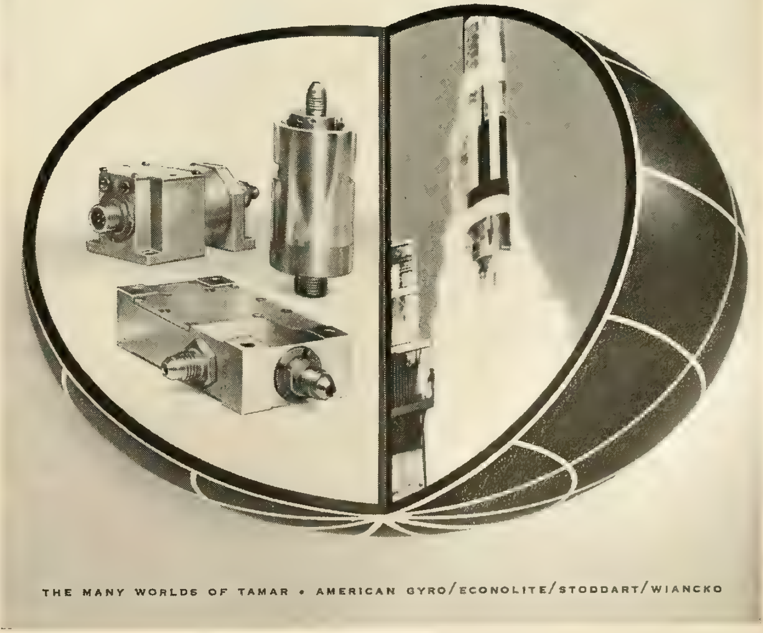

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contracts

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$5,000,000—**Sylvania Electric Products, Inc.,** Mountain View, Calif., for further work, refinement and manufacture of electronic security systems for guarding *Minuteman* ICBM sites throughout the U.S.

$1,700,000—**Aerojet-General Corp.,** Sacramento, Calif., for continued fabrication of stage II *Minuteman* rocket motors.

$1,600,000—**General Electric Co.,** New York City, for test operations at the Atlantic Missile Range, Fla.

$1,200,000—**General Motors Corp., AC Spark Plug Div.,** Milwaukee, Wis., for *Titan* II guidance system computers and component parts.

ARMY

$2,500,000—**Melpar, Inc.,** Falls Church, Va., for chemical agent warning and detection studies, and construction of prototype instrumentation to improve existing detection and alarm systems.

$1,700,000—**Raytheon Co.,** Lexington, Mass., for *Hawk* missile system engineering services. Work to be performed at Andover, Wayland and Bedford, Mass.

$1,177,000—**Varian Associates,** Palo Alto, Calif., for repairs of VA-87 klystron tubes.

$208,438—**Aircraft Armaments, Inc.,** Cockeysville, Md., for modification kits for *Sergeant* missile trainers.

$100,000—**California Computer Products, Inc.,** Anaheim, Calif., for design, development and fabrication of an automatic checkout subsystem for use in MAIDS (Multipurpose Automatic Inspection and Diagnostic System).

NAVY

$9,600,000—**Varo, Inc.,** Garland, Tex., for manufacture of the LAU-7, a missile launching system used on both Navy and Air Force warplanes.

$2,100,000—**General Electric Co.,** Pittsfield, Mass., for *Polaris* guidance system test sets.

$1,100,000—**Reeves Instrument Co.,** Garden City, N.Y., for work on components related to submarine fire-control systems.

North American Aviation's Autonetics Div., Anaheim, Calif., for supplying Ship's Inertial Navigation Systems (SINS) for *Polaris* submarines (undisclosed amount).

NASA

$2,000,000—**Lockheed Missiles and Space Co.,** Sunnyvale, Calif., for construction of a data-reduction complex for the Manned Spacecraft Center at Houston.

$670,000—**SPACE Corp.,** Dallas, for manufacture of ground-support equipment for the *Saturn* missile program.

Moore and Hanks Co., Inc., El Monte, Calif., for construction of a conventional clean-room at the George C. Marshall Space Flight Center, Ala. (undisclosed amount).

U.S. ARMS CONTROL AND DISARMAMENT AGENCY

$215,000—**Sylvania Electric Products, Inc.,** Mountain View, Calif., for conducting three non-related studies of technical aspects involved in the enforcement of possible arms control and disarmament agreements dealing with missiles and space.

DEFENSE SUPPLY AGENCY

$110,000—**Sylvania Electric Products, Inc.,** Seneca Falls, N.Y., for electronic tubes and components.

$72,747—**Sylvania Electric Products, Inc.,** Woburn, Mass., for silicon diodes EIA Type 1N1132, and semiconductor devices, Type 1N78 (two contracts).

MISCELLANEOUS

$4,500,000—**Radiation Inc.,** Melbourne, Fla., from **Grumman Aircraft Engineering Corp.,** for telemetry equipment for NASA's Lunar Excursion Module.

$2,700,000—**Marquardt Corp.,** Van Nuys, Calif., from **Ling-Temco-Vought's Aeronautics Div.,** for continuation of advanced nuclear propulsion technology in support of the Air Force's LASV program.

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The Revolution: Part I

SIGNIFICANT CHANGES now taking place in U.S. military policy and in the U.S. military organization will have a broad impact on the missile/space industry. It is not an exaggeration to say that these changes constitute as much of a revolution for the industry as was the change wrought by the advent of the ballistic missile.

The firms, both large and small, which foresee this coming revolution and adjust to it are those which will survive as the producers of this nation's next generation of weapons. For the others, quite simply, there will be no room in the industry.

To understand this development, one need only look to the industrial evolution that gave birth to the missile/space industry after World War II, an evolution which has seen it grow to rival the automotive industry in size.

The missile/space industry includes among its most successful companies those aircraft firms which saw the necessity for diversification into the nuclear, electronic and propulsion fields. It contains major electronics firms which found in missiles and space a need for a competence and knowledge unrequired by the aircraft industry. It includes companies, both large and small, which found in this new industry a requirement for new technologies and which met the need.

Once again, a moment of decision is at hand.

As a thorough study of this annual Dept. of Defense issue will reveal, the emphasis in advanced planning in the Pentagon is shifting from the large strategic systems to the needs of non-nuclear tactical warfare. This shift comes as no surprise to those who follow military strategy closely—but its significance to the industry should not be overlooked.

Decisions as important as those which diversified the prime airframe manufacturers must be made again in order to apply the technologies subsequently developed to the new situation.

Systems-oriented primes, largely concerned until now with intercontinental ballistic weapons, must determine how to bring their varied technology to bear on smaller weapons.

Lesser firms must find ways to stake a significant claim in a market where their greater flexibility to adapt is an advantage and where the shift to smaller systems restores a competitive edge which the mammoth ICBM's denied them.

Firms in the Midwest, with a steadily declining share of the industry market in recent years, will find that once again their production know-how becomes important as the emphasis shifts back from research and development to production.

Dr. Eugene C. Fubini, deputy director of Defense Research and Engineering, puts it this way: "The times when people spent their own money to develop a weapon and made their profit out of the production of a successful design seemed, and still seem, far, far away. But these times may be returning, at least in a portion of our effort."

What is that portion of our effort and what has made it so important that it can affect the structure of the industry? The answer is a complex one and it requires first a look at the foreign policy to which Secretary of Defense McNamara so closely relates the U.S. defense budget.

There is now considerable confidence at the top levels of the Pentagon in the U.S. superiority in nuclear strategic weapons and in the intelligence which assures us of that superiority.

There is sufficient confidence in that edge, and sufficient acceptance of a nuclear stalemate, so that we are engaged in what might be called a unilateral non-armament in this field. That is, we will not develop and deploy new nuclear strategic weapons until the Soviet Union gives us some reason for doing so.

Soviet deployment of an anti-ICBM system, for example, might result in a decision to procure AMPS, the advanced manned penetration aircraft, or *LASV*, the nuclear-powered low-altitude unmanned supersonic vehicle. Russian failure to deploy such a system, conversely, might keep these projects in an early development stage with only "back burner" funding against the day they might be needed.

Acceptance of a nuclear stand-off of the present nature therefore would mean that funding in the strategic package would provide only for improvements in present systems—improved penetration aids, terminal guidance, greater range, decreased vulnerability—together with sufficient emphasis in the research field to seek, or to guard against, technological breakthroughs which could alter the power balance.

Mutual acceptance of this situation by the Soviet Union and by the United States, even if unexpressed, means a corresponding emphasis on the importance of tactical non-nuclear weapons. Because there is nothing to suggest that the Soviets do not intend to continue their activity in this area—indeed, all evidence points to just the opposite conclusion.

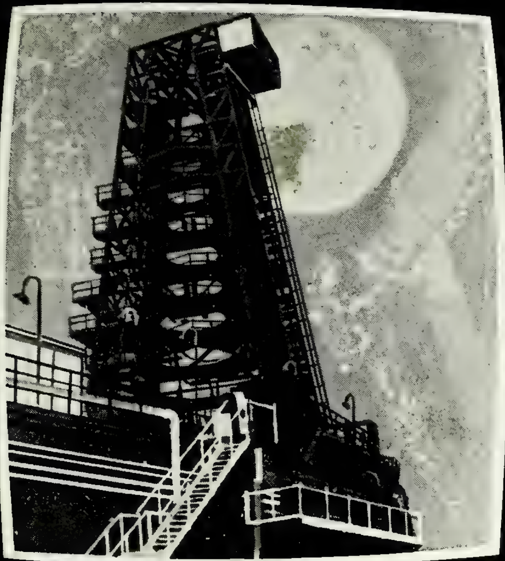
THAT IS THE CURRENT TREND of Pentagon thinking. The new emphasis is on tactical systems and on the need to bring advanced technologies to bear on the requirements of these systems.

As Dr. Fubini expresses it: "New, unmatched challenges appear in this area; we find that we have a lot of things to do. In certain areas we even need to recover some ground because we have retrogressed from where we were in World War II. We need to use our ingenuity and our intelligence to deter and, if necessary, to win these wars as well. Not enough revolutionary technical thinking has been devoted to these conflicts despite the fact that enemies still may well wish to challenge us in this field."

This emphasis on tactical systems, many of which are described in these pages, perhaps is the most significant message of this annual issue.

It presents to company management both great challenge and great opportunity. But, for the slow of foot, it is as much of an opportunity to fail as it is to succeed.

William J. Coughlin



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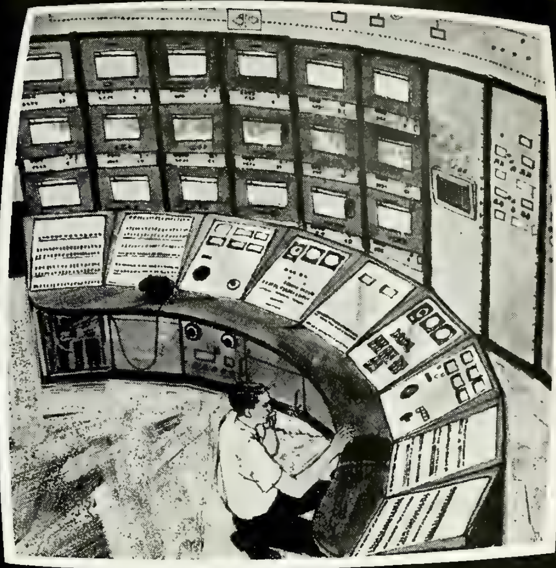

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Prime contractors for NASA's Mercury and Gemini manned orbital spacecraft and the USAF Research and Technology Division's ASSET winged reentry research spacecraft.

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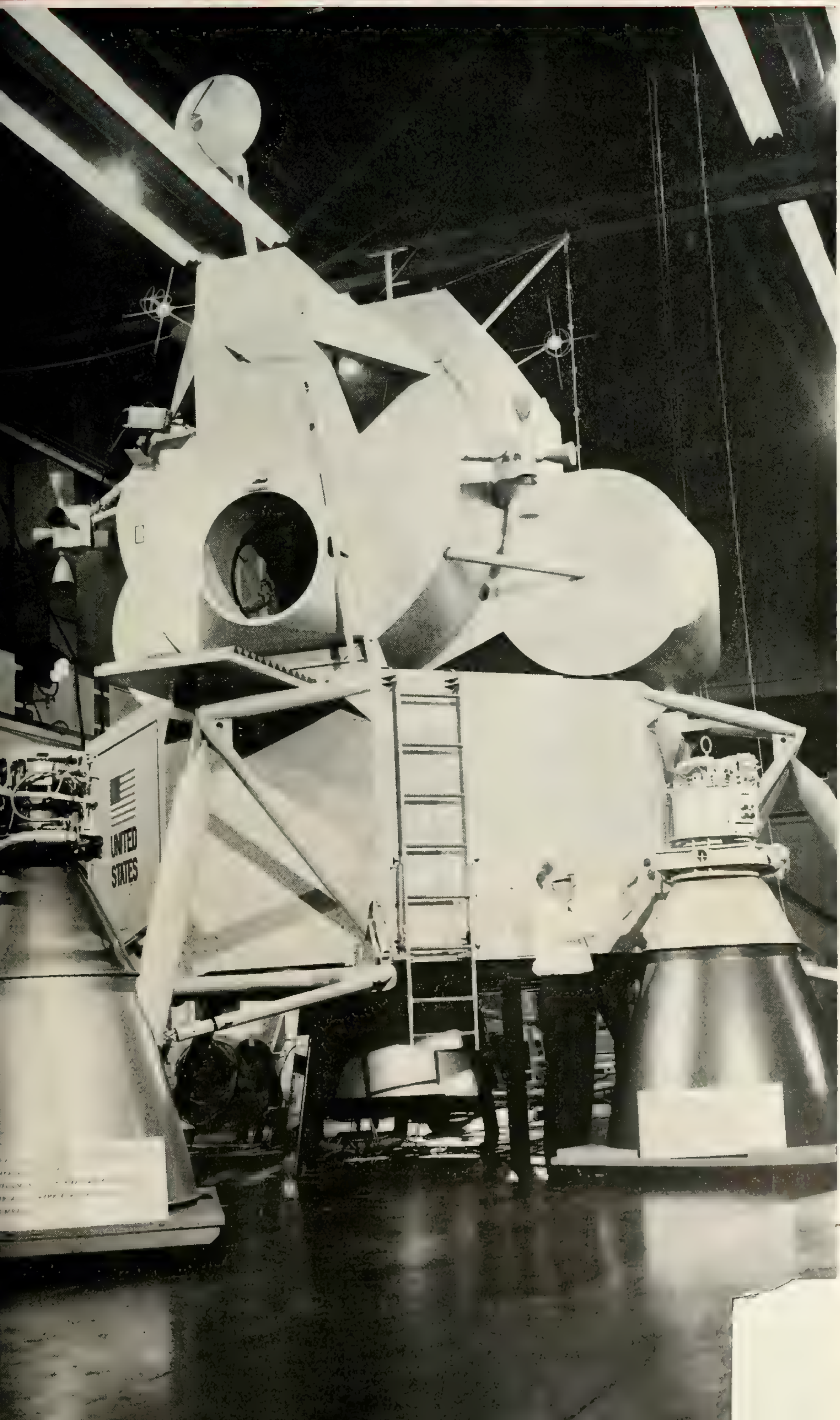
See the Mercury and Gemini Spacecraft in the McDonnell exhibit in the Missouri Pavilion at the New York World's Fair.

Circle No. 54 on Subscriber Service Card

April 6, 1964

issiles and rockets

HE WEEKLY OF SPACE SYSTEMS ENGINEERING



Navy Speeds Drive for New Tactical Missile

Ex-RAF Thors Become Boosters

S-Band System Urged for Apollo

Latest Program Plans for Gemini

Grumman Unveils First LEM Test Model

FIRE EATER

...cools hot head problems for keeps!

SCOTCH® BRAND Heavy Duty Instrumentation Tape is the name. And it takes hot recorder heads in stride by resisting tape surface temperature as high as 250°F! Shrugs off the intense, localized heat that higher tape speeds and tensions build up at recording heads. Keeps the magnetic record straight by minimizing rub-off, protecting against drop-outs.

What's more, "SCOTCH" Heavy Duty Tapes, with a special high-potency oxide and binder formulation, outwear ordinary tapes *at least* 15 times. Conductivity is greater, too. 1000 times! Drains off static before it can attract dust, cause trouble. Exclusive built-in Silicone lubrication minimizes head and tape wear. 16 different heavy-duty constructions meet all requirements, even involving extremely high speeds, short wavelengths.

TECHNICAL TALK Bulletin No. 3 discusses effects of frictional heat on tape performance as well as heavy-duty oxide and binder formulations. Free. Write 3M Magnetic Products Division, Dept. MBW-44, St. Paul 19, Minn.

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Magnetic Products Division 3M COMPANY

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magnetic tape
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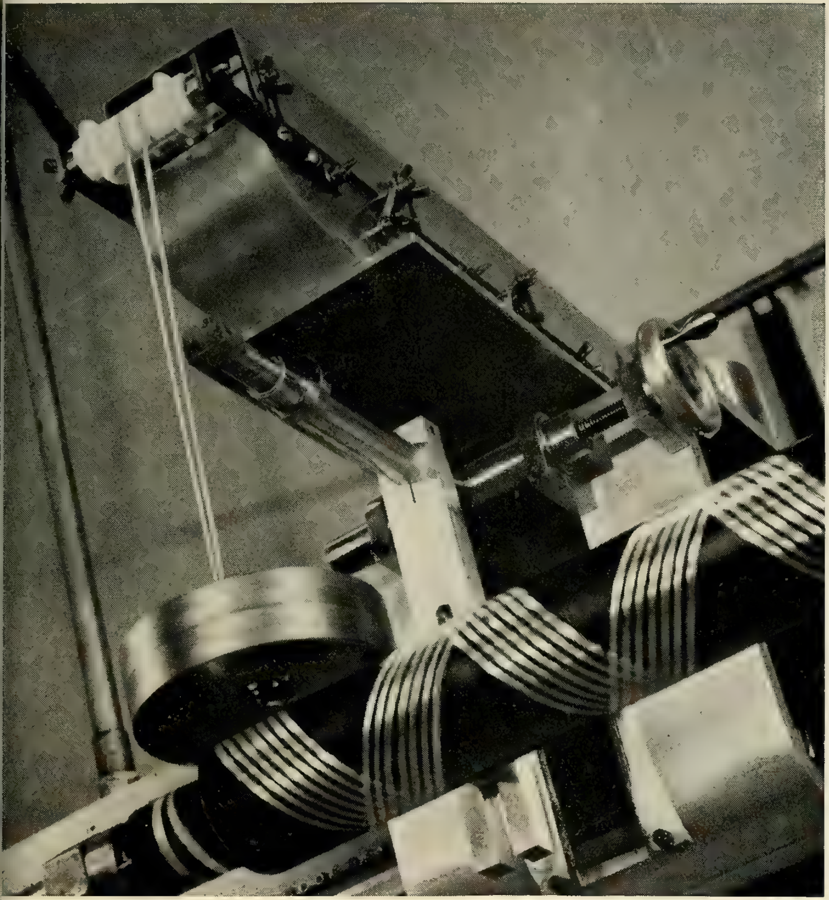
Here is Where Filament Winding Progress Begins



A unique Technical Service Laboratory for Filament Winding

In these modern facilities and with the latest technology, the problems of the customer become the problems of CIBA. To aid customers either entering or who are established in the field of filament winding, CIBA has taken another forward step by establishing a completely equipped laboratory for developing workable epoxy resin systems and techniques essential to progress in this bright and promising new industry. Whether the system preferred is wet winding or pre-preg, whether the application is military or commercial, whether the product is large or small, CIBA filament winding laboratory facilities are geared to provide practical assistance. If you are in the business of filament winding or simply would like to know more about this promising new field, write:

CIBA Products Company
Fair Lawn, New Jersey

CIBA
First in Epoxies

CIBA Araldite® Epoxy Resins. In U.S.A. and Canada CIBA produces basic resins only, to be formulated for intermediate and end uses.

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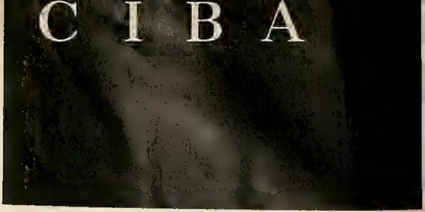
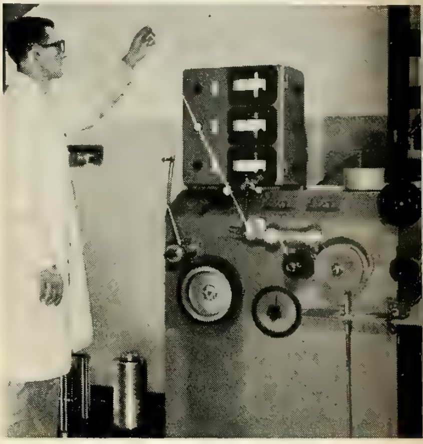
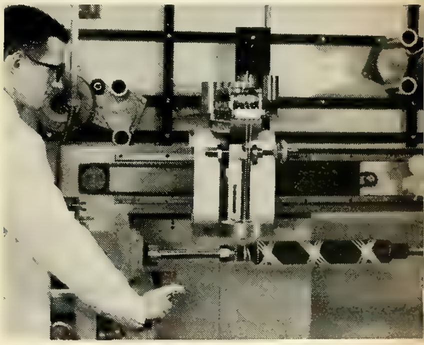


Pre-Preg Machine. Pre-impregnated roving can be fabricated under rigidly controlled conditions.

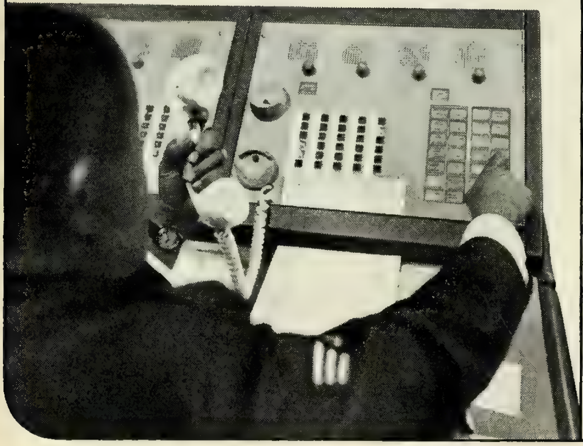


Filament Winding Machinery. Versatile, advanced equipment is used by CIBA for checking systems, patterns, and properties.

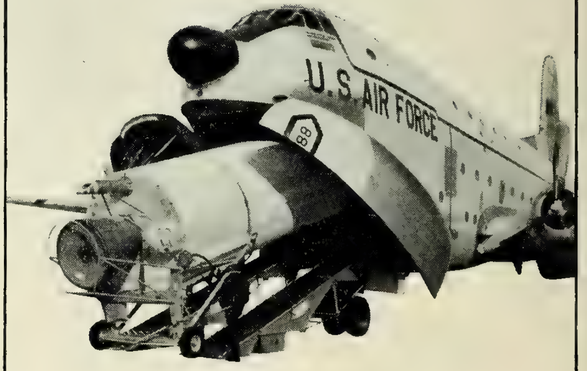


Hydrostatic Burst Equipment. Tests pressure vessels, pipe and subscale missile cases at room and elevated temperatures.

9:07 Request for missile



9:08 Action!



A new telephone communications network is playing a vital role in support of U. S. aerospace power around the globe. Called the Air Force Logistics Command Operations Network (AFLCON), it is tailored to exacting military needs.

AFLCON is used to maintain stockpiles of all materials needed to support aircraft and missile bases by linking Logistics Command Headquarters with the principal supply centers.

Specially designed consoles and switching units quickly handle emergency calls by commanders, conference calls among key groups, and alerts in a military crisis.

At a glance, visible signals tell which circuits are busy. Push-button controls monitor all circuits and permit calls to be challenged for the priority network. And within seconds, telephones in the offices or residences of key officers can be connected individually or in conference to local circuits or to one or more of the network stations.

Automatically all messages are recorded for replay whenever needed. During actual operations, other built-in speakers are used to monitor the various network circuits.

AFLCON is a unique system custom-designed for a specific need. The development of such specialized communications is an example of the Bell System's ability to coordinate the skills of engineering and manufacturing.

So too, in its primary function, is the Bell System constantly improving the communications network which must serve a growing nation. And in doing so, it is also strengthening the defenses of the nation.

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missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING

Volume 14, Number 14

April 6, 1964

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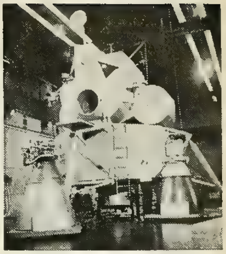

First Lunar Excursion Module test model is shown at Grumman Aircraft Engineering Corp., along with mockups of descent engines. Engines are being developed in parallel competition by North American's Rocketdyne Div. (mockup at left) and TRW Space Technology Laboratories. Decision on engine will be made later this year. See story, p. 26.

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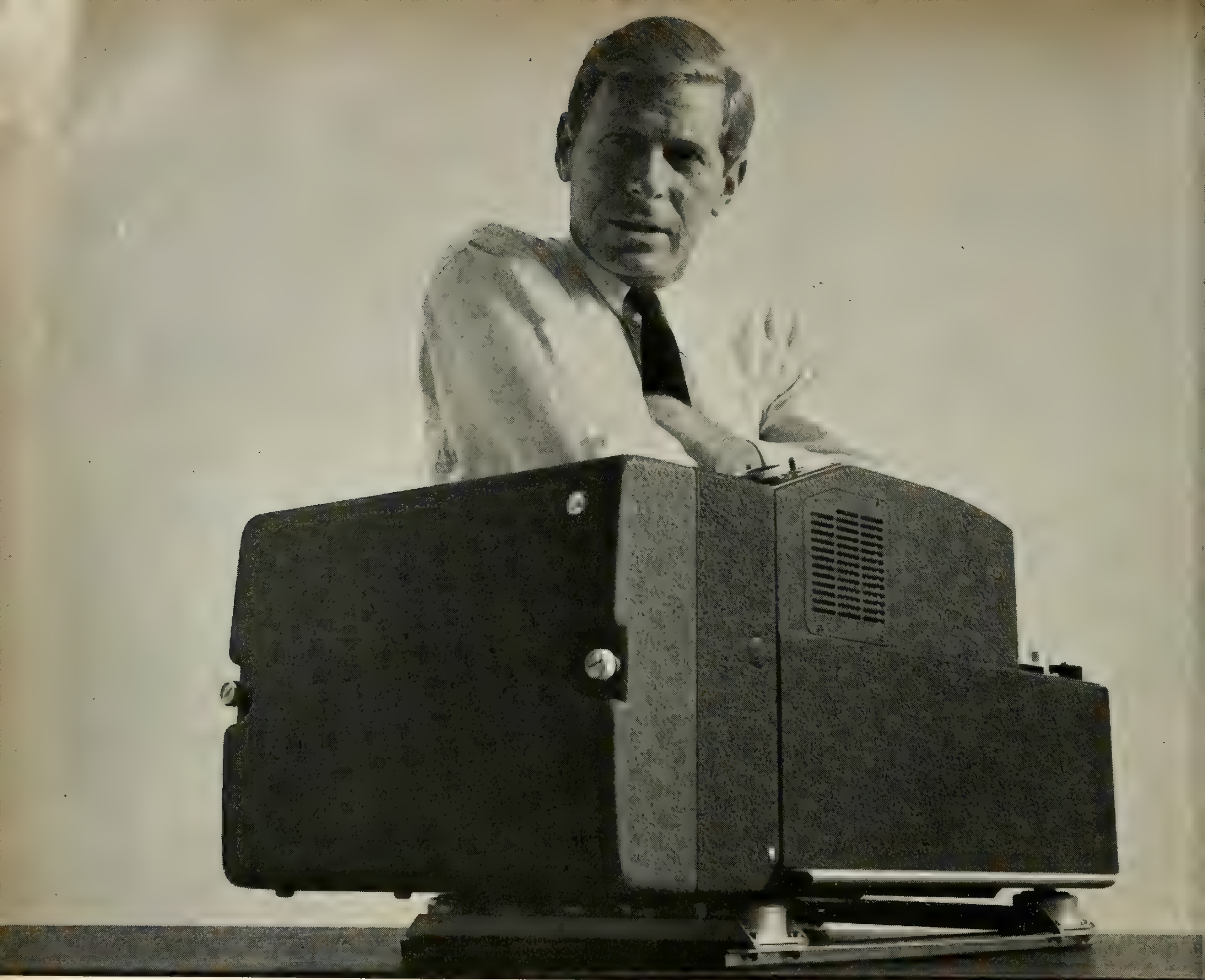

We gave them our best – but they wanted more

We had given our customers the world's finest oscillograph. It was accurate, rugged and reliable beyond compare – and it could simultaneously produce 26 different channels of test data. But progress was demanding a new standard.

The race for space was making the field of dynamic measurement increasingly complicated. Every day brought new temperature, pressure, velocity and acceleration tests. An oscillograph was urgently needed that could do everything CEC's "Old Faithful" could do – and do it with *twice* as many recording channels.

But how do you double the recording capacity of an oscillograph – design it to accept all photographic media (conventional paper, film and print-out-paper) – and still keep it small enough to be practical? Our engineers had an immediate answer: "We aren't sure." After many months of constant development, trial and error – they still weren't sure.

Then came their final answer: "We've got it." That was more than eight years ago. Now the world's first "universal" oscillograph is a trusted friend to virtually every installation where advanced oscillography is required.

This is a "graphic" example of how customer demands are setting new standards – and will continue to set them. And it explains why CEC has remained the leader in the development and production of all phases of data recording.

It's also the reason why CEC maintains a network of 22 sales and service offices throughout the nation. To expedite application engineering; and to help train customer personnel in the use of advanced instrumentation.

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A new "must" for engineers

Measuring 21″ x 27″, and schematically arranged, the new CEC chart covers in detail each instrument in the four categories shown below. This includes basic specifications, cross-reference tables to aid in selection of instrumentation, and information on how to use *combinations* of the various instruments to meet specific needs. In addition, the chart describes the finest support equipment for dynamic measuring and recording in industrial and military applications.

Sensors and Pickups

Chart shows the 43 available for pressure, vibration, acceleration.

Signal Conditioners

Chart shows 11 basic types and where they may be required.

Magnetic Tape

Chart shows 8 analog and digital recorder/reproducers with support equipment.

Direct Readout

Chart shows 5 recording oscillographs, 33 galvanometers and where they can be used. Also support equipment.

Please write today while sufficient copies are still available. Ask for CEC Chart DM-37-X28.

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Circle No. 9 on Subscriber Service Card

letters

Canoga Radar Tracking

To the Editor:

We were indeed pleased at the interest shown by M/R in our Editar-Radar Long-Range Tracking System, described in your special electronics section (Feb. 17, p. 31).

In view of the general technical excellence of the article, we are reluctant to call to your attention two points which should be brought to the attention of your readers to avoid creating a wrong impression.

First, the title of the article states that "accuracy of Canoga radar tracking system is 6 feet in 30,000 miles." The word "resolution" should be substituted for "accuracy." The Editar does indeed provide data with a resolution of 6 ft., but the accuracy of a radar system is affected by many factors other than the granularity of the ranging system. Since Canoga's design responsibility was limited to the ranging system, we can make no claims for overall radar accuracy.

Secondly, the writer was attributed with the view that a "digital computer could replace the present Editar." Lest the general reader gain the impression that in Editar we created a boondoggle, we must hasten to state that Editar and the general-purpose computer are not interchangeable. About half of the original Editar system comprised what would amount to a special-purpose digital computer. It is this portion which could be replaced by the general-purpose computer, and such a step would indeed provide Editar with a flexibility not possessed by the original system. At the time Editar was designed, however, a suitable general-purpose computer was not available. In any case, the target tracking section of Editar, which provides it with its excellent dynamic capabilities, is its key element and will be used in future systems.

Finally, may we point out that Editar has not automated the radar operator out of a job. Editar does, however, relieve the operator of having to manually adjust the tracking servo bandwidth as tracking conditions change.

J. H. Werlin
Manager, Digital Products
Canoga Electronics Corp.
Canoga Park, Calif.

Polaris Guidance

To the Editor:

This is written to comment on certain statements made by Mr. Frederick J. Howard in his letter to the editor (M/R, March 16, p. 5).

1. The *Polaris* Guidance Shipping Container was designed by private industry (General Electric).
2. The guidance system Mr. Howard had reference to is the first-generation *Polaris* Guidance System.

As far as MIT's past record in system engineering is concerned, the excellent performance of the *Polaris* Guidance is a matter of public record and details of its performance are available to anyone with a need-to-know.

Samuel A. Forter
Associate Director
Instrumentation Laboratory
Massachusetts Institute of Technology
Cambridge

To the Editor:

If you can't print a more worthwhile defense of your usually inane editorials than Mr. Howard's letter, I suggest you cease publication of that particular department of MISSILES AND ROCKETS. Mr. Howard's letter is the first illustration I can recall which evaluates the performance of a guidance system development on the totally absurd basis of its transit case weight. Anyone even remotely associated with guidance systems would recognize the *Polaris* guidance development as a most significant technological breakthrough.

A. Daniel Eliason
Fort Worth, Tex.

Apollo G&N

To the Editor:

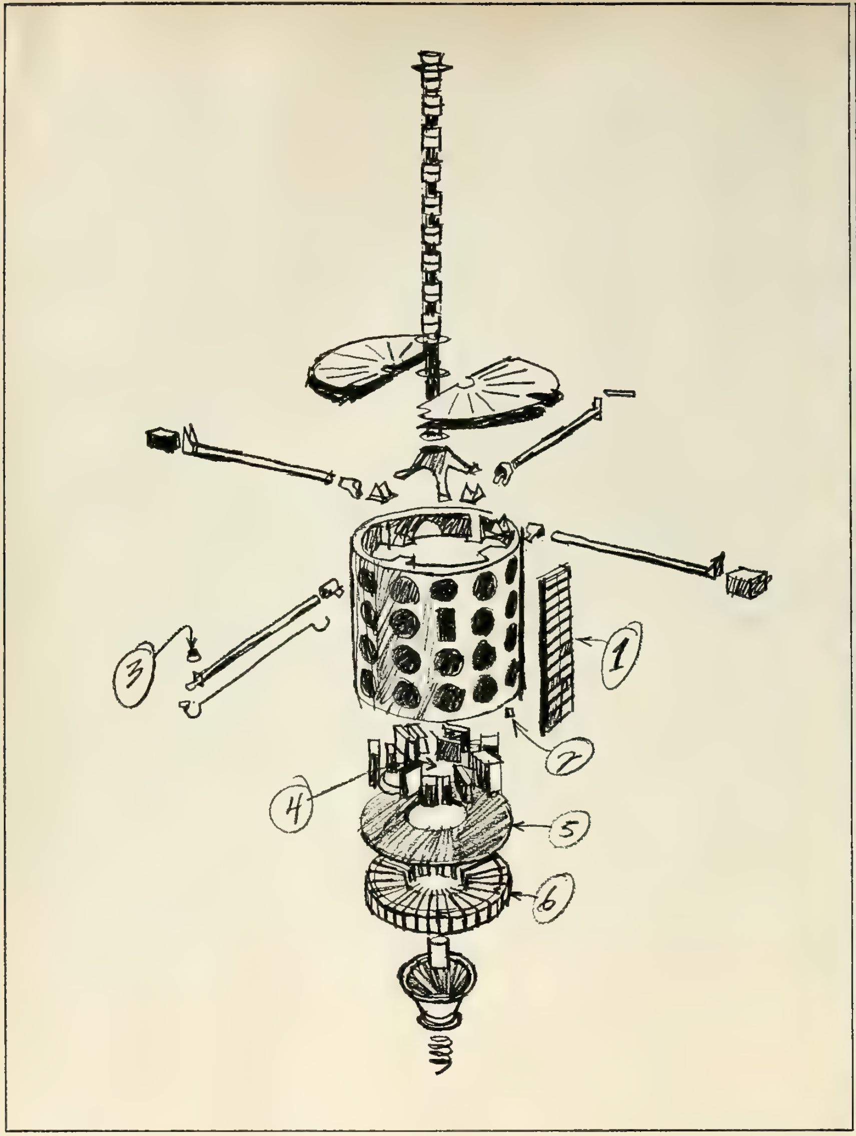
In an article in the March 16 issue ("New Apollo Guidance System Could Become Standard for Future," p. 28), reference was made to a "mountain of paper work" existing in the *Apollo* Guidance and Navigation program. This statement is not only misleading in its inference but particularly unjust in light of the facts.

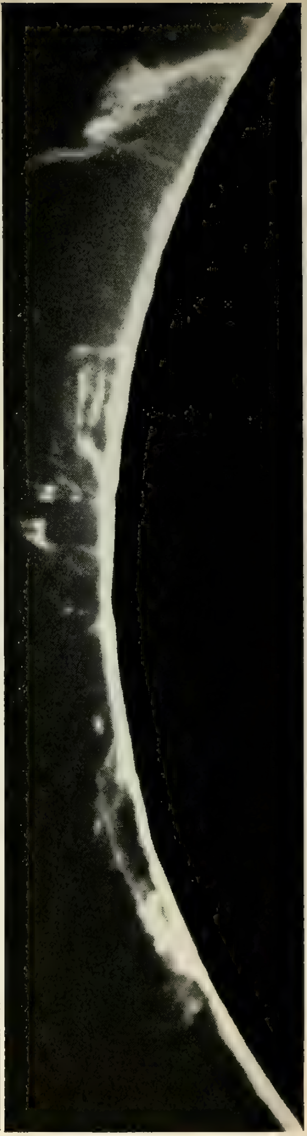
The Guidance and Navigation program, under the design cognizance of MIT's Instrumentation Laboratory, was the first *Apollo* program to introduce the microfilm-punched-card method of information retrieval for its technical documentation. This requirement was conceived and implemented over two years ago by MIT, but was only recently made a requirement by NASA for other areas of the *Apollo* program. To date, all of the technical documentation in use on the *Apollo* Guidance and Navigation program, including all design, test, production, operation, maintenance and qualification communication, is filed in a space no larger than a small chair.

In addition, MIT's Instrumentation Laboratory has evolved and introduced, in both the *Polaris* and the *Apollo* programs, information management systems and techniques of such acknowledged value that they have already been emulated.

I would also like to point out that the goal in an industry hard-pressed for profits should be continually to seek more efficient methods of managing the vast amounts of technical data needed for today's complex systems. The solution is not to avoid the problem by eliminating the communication. That would not postpone the problem until it became catastrophic. MIT, as a non-profit organization, has been in the forefront of information system development.

Jack B. Goldman
Cambridge, Mass.





WE'RE PUTTING A NEW PIONEER TOGETHER AT STL

About the only similarity between the old and new Pioneer is the name. When it is launched in early 1965, the new vehicle will gather a much broader range of space data than did Pioneer V—but with only slight increase in weight. The Pioneer's newfound efficiency results from many design advances that allow more room for scientific payload. Maximum power from the 10,000-cell solar array (1) is assured by sun sensors (2) and a reorientation nozzle (3) which keep spin axis normal to sun line. Thermal design is simplified by mounting all electronic equipment (4) on a single shelf (5) above the heat control louvres (6). These are just a few of the improvements built into the new Pioneer by STL. Today STL is busy on many space projects that mean new job opportunities for engineers and scientists. STL is prime contractor for NASA's OGO and Pioneer programs, and for the Air Force-ARPA tandem nuclear detection satellites. STL is developing the variable-thrust descent engines for Apollo and Surveyor lunar landings. And STL continues Systems Management for the Air Force's Atlas, Titan and Minuteman programs. These and other space and missile activities create immediate openings in: Theoretical Physics, Systems Engineering, Radar Systems, Experimental Physics, Applied Mathematics, Space Communications, Space Physics, Antennas and Microwaves, Inertial Guidance, Analog Computers, Solid State Physics, Computer Design, Telecommunications, Digital Computers, Guidance and Navigation, Electromechanical Devices, Engineering Mechanics, Applied Aerodynamics and Propulsion Systems.

For information about Positions in Cape Kennedy or Southern California, including STL's new Capistrano Test Site, write STL Professional Placement, One Space Park, Department B-4, Redondo Beach, Calif. TRW is an equal opportunity employer.

TRW **SPACE TECHNOLOGY LABORATORIES**
THOMPSON RAMO WOOLDRIDGE INC.

The Countdown

WASHINGTON

Apollo Price Tag Hits $4.8 Billion

NASA now estimates the total cost of the *Apollo* spacecraft at $4.8 billion—with more than 50% still to be funded after Fiscal 1965. The latter includes $1.3 billion for the Command and Service modules, $455 million for the Lunar Excursion Module, $192.6 million for the guidance and navigation system, $12.7 million for instrumentation and scientific equipment, and $541 million for spacecraft support.

AF Studies Military Fallout from Apollo . . .

The Air Force has conducted a study—scheduled to go to the Joint Chiefs of Staff about April 1—on the benefits to the military of NASA's *Apollo* program. Of special interest are the space agency's experience with long-lived guidance systems, large boosters, and man in space—particularly in the *Gemini* project.

. . . And U.S. ICBM Posture

Air Force's Ballistic Systems Division is now engaged in a comprehensive study of the U.S. ICBM force—its qualitative role, its reliability and its vulnerability. The in-depth analysis is to be completed within two to three weeks. Answering questions about ICBM reliability, BSD commander Maj. Gen. W. Austin Davis says all U.S. ICBM's have met or exceeded their specific operational requirements and that "the facts are that the ballistic missiles today can do their mission."

Committee Insistent on SNAP Flight Funds

The Joint (Congressional) Committee on Atomic Energy is expected to vote money for flight tests of the SNAP-10A nuclear reactor, despite the recent Air Force withdrawal—apparently under pressure from the Budget Bureau—of flight-testing requirements (M/R, March 2, p. 24). Committee vice chairman Rep. Chet Holifield (D-Calif.) has again affirmed that he is "pushing very hard" for flight funds.

Thresher Loss Delayed Subroc

One of the untoward consequences of the sinking of the submarine Thresher last year was a delay in operational evaluation of the Goodyear *Subroc* antisubmarine missile. Thresher was specially outfitted for testing the missile; after it was lost, SSN Plunger had to be refitted for the tests. Now, however, *Subroc* evaluation is nearly complete and the missile will be installed on 31 ships—including all nuclear attack subs—beginning in 1965.

Lance Using New Warhead Principle

In addition to nuclear and chemical warhead capability, the Army's LTV *Lance* missile will have a conventional warhead of unique design. Rather than a single large high-explosive charge, the highly accurate surface-to-surface weapon will employ a large number of "bomblets"—1,000 individual HE charges which are dispersed over the target and improve both lethality and area coverage.

MMRBM Backers Live and Kicking

West Coast supporters of the *Mobile Medium Range Ballistic Missile* continue to hope that Congress will take another look at its cutback of the program. The Air Force still believes there's a strong requirement for the weapon. BSD commander Maj. Gen. W. Austin Davis admits that the picture is dark right now, but he says, "the fight is not over. There is a very good chance we will have an *MMRBM* development program."

INDUSTRY

New Support Contract Policy at MSFC

Marshall Space Flight Center is starting a new policy toward support contractors which could spread throughout the agency. Officials have served notice that in the future each laboratory at the center will have only one major contractor in the support area, rather than several performing different functions, as is the current practice. All such current contracts will be phased out and new bids requested. This does not preclude a prime contractor's subcontracting part of the support services.

Atlas-Centaur Foiled by Panel Troubles

The *Atlas-Centaur* launch scheduled at Cape Kennedy April 8 is off at least until April 14 because of failure of three West Coast tests of insulation panel jettisoning. It's believed that the helium purge that keeps the panels from freezing to the stage has not been uniform. Launch won't be okayed until there are three successful jettison tests.

Minuteman Circuits Available to All

The range of 18 circuits supplied for the *Improved Minuteman* digital computer by Texas Instruments Inc., of Dallas, can now be bought as catalog items at prices varying from $22 to $170—thanks to increased production yields. In the first quarter of this year TI's production of the integrated circuits reached an average of just over 45,000 per month. Toward the end of the quarter, production capability for another 12,000 a month became available. The situation contrasts sharply with mid-1963, when production ran far behind customer requirements. Cecil P. Dotson, TI vice president in charge of Semiconductor Components, says yields are now averaging 15-20%.

INTERNATIONAL

Worldwide ComSat Battle Lines Drawn?

Sixteen European and British Commonwealth governments are reported to have agreed to join in an international satellite communications system, as proposed by the U.S. ComSat Corp., only if the system is internationally controlled and permits all member nations to participate in design and construction of satellites and launch vehicles. ComSat Corp. wants to have a free hand in running any international system. Representatives of the 16 nations—believed to include most if not all of the ELDO countries—reportedly reached the agreement at an unpublicized meeting in London and will take this stand at the Washington conference this month.

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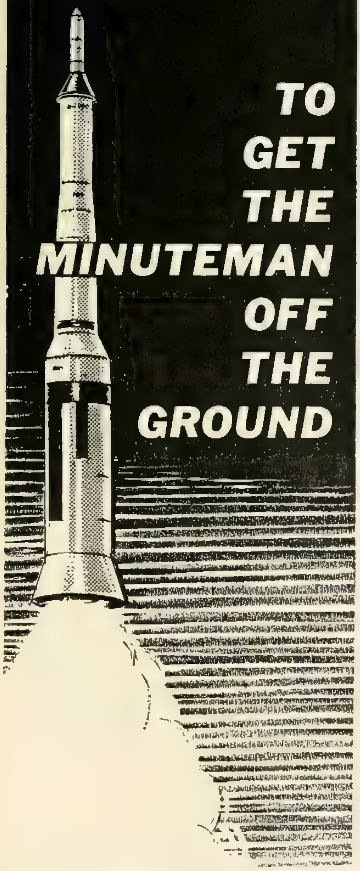

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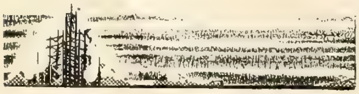

The Missile/Space Week

Tory II-C Termed 'Flyable'

The only requirement remaining for development of an unmanned nuclear-powered low-altitude supersonic vehicle capable of nuclear bombing over a global range and under enemy radars is a program go-ahead, according to AEC spokesmen.

AEC left no doubt of its feelings on this at a Nevada test site press briefing on the Tory II-C reactor. The reactor, described as "flight capable" by AEC, will undergo a series of full-power tests starting this spring.

Dr. Harry Reynolds of Lawrence Radiation Laboratory, one of the chiefs of the Pluto program to develop a reactor for a nuclear ramjet system, told MISSILES AND ROCKETS the Tory II-C reactor was "flyable. If we had a missile for it, it would fly." He expressed confidence the forthcoming tests would support this feeling, pointing out that the smaller Tory II-A test reactor, tested in 1961, proved the technical feasibility.

"We would use Tory II-C if we had to fly a test vehicle in as short as possible a time," Reynolds told M/R. "If we had a little more time, we would make improvements, and if we had more time, up to a year, we would use Tory III." Very little work, even on paper, is being conducted on Tory III at this time, he said.

Shots of the Week

NASA-supplied *Scout* rocket vehicles carried aloft two foreign payloads Mar. 25 and 27. The first Italian *Shotput* probe was launched on the 25th from a mobile platform anchored off the coast of Kenya in the Indian Ocean. Shot was preparatory to an Italian effort (Project San Marco) to put a satellite into polar orbit. A *Scout* was also used to launch Britain's *Ariel II* (*UK2*) satellite from Wallops Island, Va., Mar. 27. Shot was second in a series of three to make investigations in and above the ionosphere.

- NASA test pilot Air Force Maj. Bob Rushworth flew the *X-15* rocket plane from Edwards AFB, Calif., Mar. 27 in a test to determine the effect of shock waves on photographs taken by a camera traveling 3,000 mph.
- The Soviet Union launched *Cosmos 27* on the 27th. Shot was the third in the *Cosmos* series this year. Period is 88.7 minutes; apogee, 237 km; perigee, 192 km.
- The Air Force on the 31st sent a *Nike-Javelin* off in the wake of a *Minuteman* ICBM launched 30 seconds before from Cape Kennedy. The *Javelin* was to gather data on missile exhaust. Firing was the opener in a 16-shot series in the study.
- A further exhaust study shot was conducted Apr. 1 when an *Atlas-ABRES* was launched from Cape Kennedy carrying with it a General Electric re-entry vehicle and two scientific passenger pods. One pod fired two small rockets backward along the *Atlas* exhaust plume to study infrared radiation characteristics. The other contained eight scientific experiments to study the ionosphere, the magnetosphere and radio frequency noises for extraterrestrial sources.

DDR&E Criticism Refuted

More than 300 projects or military system "starts" have been initiated under the McNamara-Brown Pentagon administration, Dr. Eugene Fubini, Asst. Secretary of Defense and Deputy Director of DDR&E told a meeting of the Washington, D.C., chapter of the American Institute of Aeronautics and Astronautics. Answering industry and public criticism that no new systems have been started in the past three years, Fubini showed the audience a nine-page classified list of new projects.

Noting that its contents were classified, he said that there were approximately 35 projects listed on each page. Fubini countered the no-new-systems criticism with the question "How many systems has industry finished?"

"We'll give you (industry) a new system for every one you finish," he offered, noting that he feels that DDR&E's list of completions will be at least as impressive as industry's under current Pentagon policies.

RAM Due for Launch

NASA has scheduled the launch of a 250-lb. instrumented *Radio Attenuation Measurement (RAM)* spacecraft on a suborbital flight from Wallops Island, Va., no sooner than Apr. 7.

The experiment is one in a series to study the problem of communicating through the ionized plasmas created when a spacecraft re-enters the Earth's atmosphere at high velocities.

The ionized plasmas generated by a re-entering spacecraft can act as a shield to completely black out communications.

The *RAM* flight experiments are being made to gather data on the properties and behavior of the ionized plasma and to develop techniques to solve the communications blackout problem.

Space Chamber Test Completed

Five men who were confined for 30 days in a space environment simulation chamber at the Boeing Co. in Seattle (M/R, Jan. 27, p. 28) emerged April 1 in apparently excellent health. They are now undergoing medical tests.

NASA's Dr. Eugene Konecci said, however, that levels of microbe toxicity were much higher than anticipated, and this may point to problems in the future. In the Boeing experiment, charcoal filters and burners were used to counter the threat.

Boeing research specialist Robert Page said that in general all systems performed very well, although there were some difficulties with the closed shower cycle.

New Space Group Convenes

The newly created Science and Technology Advisory Committee for Manned Space Flight convened Mar. 30 for the first time at the John F. Kennedy Space Center.

The committee will function in advisory capacity to Dr. George E. Mueller, NASA Associate Administrator for Manned Space Flight. It will advise on the scientific and technological content of the manned space flight program and on methods of obtaining maximum utilization of scientific and engineering talent and knowledge required for the successful accomplishment of the manned spaceflight program.

Rocketdyne Gets F-1 Pact

Rocketdyne Div. of North American Aviation Inc. has been awarded a contract valued at $158,466,800 for the production of seventy-six F-1 engines.

The contract definitizes a letter contract signed by NASA with the firm in June 1962 under which $31 million has already been paid to the company.

The F-1 engines will be used to power the *Saturn V* booster.

How high is your goal?

Ours are out of sight—in the labyrinth of space. But your opportunities are a tangible reality, here and now, at North American's Space and Information Systems Division.

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Generate design criteria on spacecraft and launch vehicle considering entire load spectrum of ground handling, launch, orbital rendezvous, space flight, re-entry, and landing. Make preliminary design analysis of spacecraft structures involving determination of basic load path, strength characteristics and effective trade-off studies. BS in engineering with five or more years experience in preliminary structural design analysis.

Spacecraft structural load analysis including evaluation of dynamic loads through the entire load spectrum—pre-launch, lift-off, boost, separation (abort), docking, re-entry, landing, and recovery. BS in Aero, ME, and five to ten years experience in aerospace structural loads and criteria.

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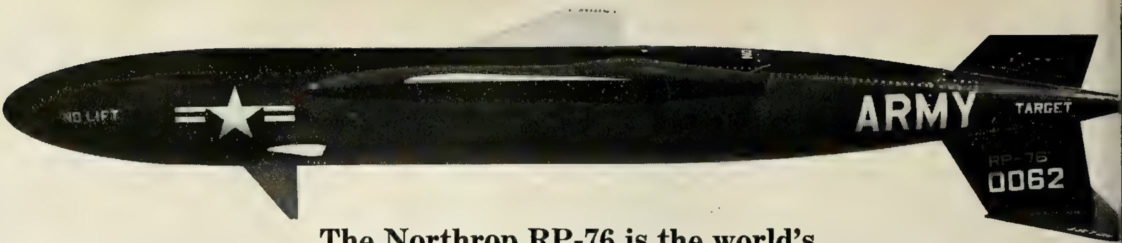

The Northrop RP-76 is the world's
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It has flown over 2000 missions
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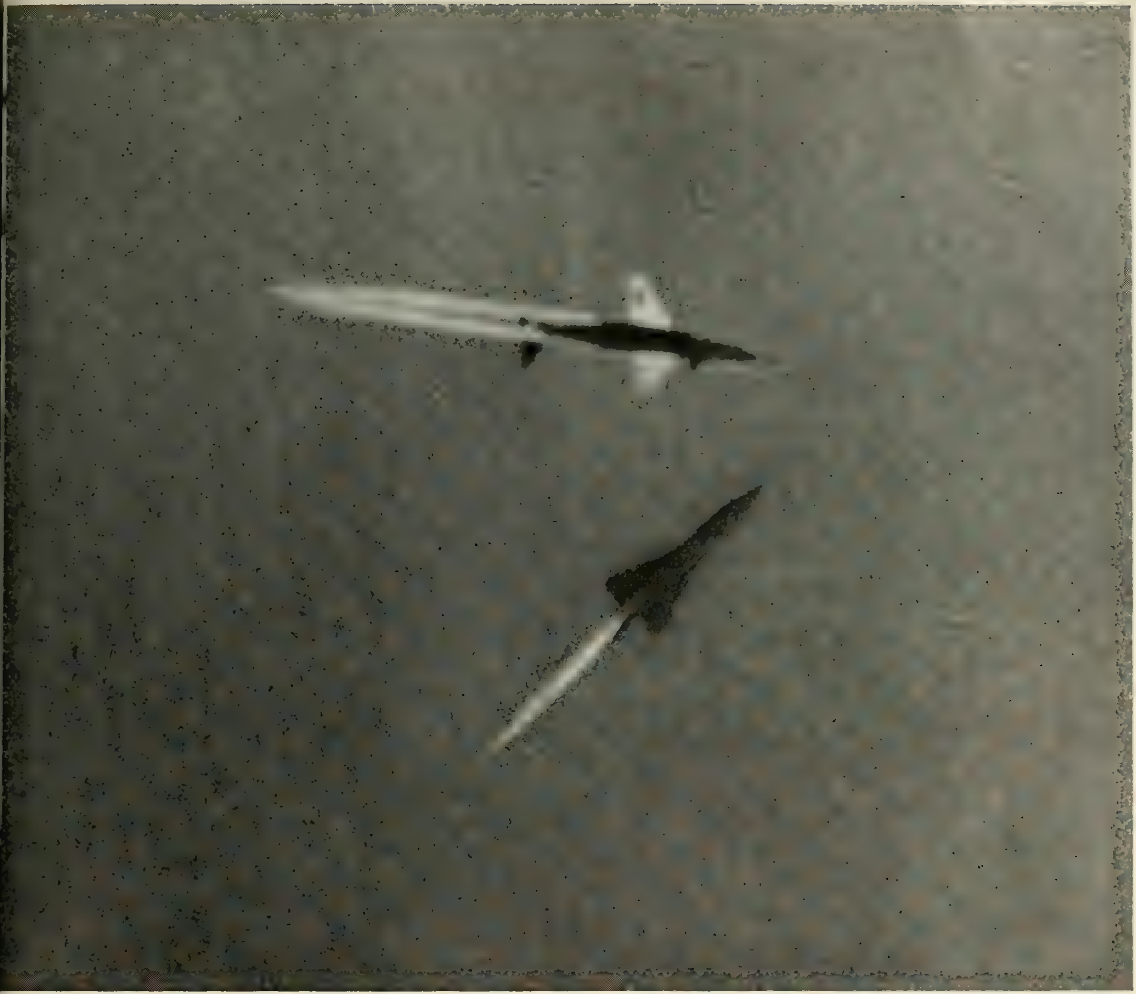
It performs realistically
at high and low levels.

And it has the lowest cost per mission of any missile target system.



That makes it a natural prey for the Hawk.

The RP-76 provides the most effective exercise for he Hawk missile short of combat. To a Hawk, it ooks, flies and maneuvers like an enemy plane. Yet, nlike most realistic targets, it can be destroyed withut prohibitive cost.

Northrop has provided complete RP-76 target servces for U.S. and NATO forces in the United States, the Pacific and the Far East. This target service included all flight operations, launching, control, tracking, scoring, repair and maintenance.

Past experience and proven performance make the RP-76 the most realistic enemy the Hawk could encounter. **NORTHROP RP-76**

Deployment by 1971-72 . . .

Navy Presses for New Missile

Norden wins guidance system contract for close-support weapon for amphibious landings; development to cost $75 million

by James Trainor

A NEW SHIP-TO-SHORE missile system for close support of amphibious landings moved one step closer to reality March 31 with the signing of a contract for development of the weapon's guidance system.

Under terms of the still-unannounced contract, the Norden Div. of United Aircraft Corp. will build and deliver five guidance packages to the Applied Physics Laboratory of Johns Hopkins University, presently handling the program for the Navy's Bureau of Weapons.

Three of the systems will be flight-tested this year as passengers aboard *Sergeant* missiles. If the flight test program is successful, the Navy hopes to enter program definition on the close-support weapon early next year, with approval for development following in time for the Fiscal '66 budget. The system is being carried as a line item in the FY '66 program.

Development is expected to cost more than $75 million. Navy officials refused to speculate on the procurement costs, but one estimate puts the total buy at approximately 400-500 missiles, at a unit cost of $40,000-50,000.

Deployment of the system is not expected before 1970, and more likely 1971-72.

- **Terrier-limited missile**—One of the primary requirements for the weapon is that it be compatible with *Terrier* shipboard installations—launchers, magazines and loading systems.

The Navy has 25 ships equipped with *Terrier*, one with both *Talos* and *Terrier* and 13 ships either under construction or approved for construction or conversion. Most of these ships are frigates or cruisers.

To be compatible with *Terrier* launch equipment, the close support weapon could be 12 in. dia., 15 ft. long (27 ft. if a booster is used to increase range) and could weigh as much as 3,000 lbs.

The missile will use solid propellants and a high-explosive warhead. It will have a range of at least 30 miles.

- **Stringent accuracy a hurdle**—One of the requirements that has delayed development is the precise accuracy specified. Although APL has been working on the system since 1959, it was not until late last year that they felt the accuracy requirements could be met with a reasonably low-cost guidance system.

In November, the Navy requested proposals from industry for a low-cost guidance package that could meet its accuracy requirements and at the same time would not require an expensive development program.

After evaluating the 12 proposals received, BuWeps and APL reduced the number to three. The three proposals were so close, one official noted, that final selection hinged on which one promised the least risk both in terms of development and cost. Pre-award surveys were also conducted to verify cost estimates.

- **Inertial platform details**—Norden's inertial platform centers around a low-cost, single-degree-of-freedom, rate-integrating gyro. Nicknamed the "jittering jewel" because jewels are used in the bearing mechanism, the floated gyro can absorb a high degree of vibration and shock. Weighing only one pound, the gyro operates between temperatures of 40° and 160°F without temperature control, and has a short-term random drift rate ($1\ \sigma$) of 1.5°/hr. The special output axis bearings are used to reduce friction, improve performance and reduce cost.

Production cost of the inertial platform is expected to be $10,000-12,000. The Norden contract for five systems runs for one year and is valued at about $570,000.

- **Guidance problems**—Three problems contribute to the guidance difficulty: position of the ship relative to the shore, accuracy of the inertial guidance system and the requirement for terminal guidance.

Determining ship location relative to the shore and maintaining that reference can be solved with present navigational techniques without resort to new equipment, Navy officials feel. The accuracy of this determination is one of the reasons the guidance system must be extremely accurate to compensate for ship location errors.

The *Sergeant* flight test program at White Sands will provide data on guidance system performance.

Finally, the Navy plans to build a breadboard model of an acquisition terminal guidance command link and demonstrate its performance. By eliminating the man in the system, the Navy hopes to avoid the difficulties the Army encountered with *Lacrosse*.

The system developed by APL would involve a command link that would acquire the missile anywhere within a cone approximately a mile in diameter at 30,000 ft. Position of the target would be determined by a forward observer and cranked into the command link so that final corrections could be transmitted to the missile before impact. The breadboard demonstration is likely to involve acquisition of a target aircraft carrying guidance components for the missile system.

- **Filling the gap**—With the urgency of the fleet air defense requirement after World War II, close support requirements were neglected. Now, there is general recognition that more attention must be paid to amphibious support. Improved guns are now being developed and the close support weapon is also being pursued to rectify this situation.

One of the obstacles to development of the missile system is the Director of Defense Research and Engineering's insistence that the Navy look at the Army's *Lance* for the solution to its requirements. Navy officials, however, feel that *Lance* is not accurate enough, and is spin-stabilized, which precludes terminal guidance, uses storable liquid propellants not suitable for shipboard storage, and is not compatible with shipboard launch systems. ■

Unearned profits charged . . .

Senate Report Urges New Missile Buying Approach

by Heather M. David

SENATE INVESTIGATORS have asked the President to appoint a high-level study group to "reassess the government's procurement practices." They charged that large unearned profits have been collected by major weapons system contractors.

In a highly critical report, the Permanent Subcommittee on Investigations of the Senate Government Operations Committee called for a thorough reexamination of the basic relationship between the government and big missile manufacturers. It suggested that Congress should consider changes in laws and regulations "that will permit the most economical method of acquiring weapons systems."

The group indicated that some sort of government administration of the missile industry might be necessary. It pointed out that at different points in time it had become necessary to create utilities commissions for the administration of monopolies in gas, water, electricity and the like "in order to operate in the best interests of the public." Later, "similar problems were solved for the telephone and air transportation industries."

"The subcommittee believes that in the weapons industry, insofar as acquiring complete systems is concerned, a similar point in time has been reached. Ways must be found again to protect the public and at the same time to reward by adequate profits the efficient operation of these necessary monopolies," the report said.

Although the report questioned actions of the companies and branches of the armed services who participated in the missile programs studied, it emphasized that the basic criticism was with the method of procurement.

The committee also made clear that it did not intend to "impute any unlawful act or unconscionable conduct to the companies or individuals mentioned. These missile systems were bought under the methods then available."

- **Defenders**—Dissenting views were voiced by Sen. Carl T. Curtis (R-Neb.) and Sam J. Ervin, Jr. (D-N.C.). Curtis said that it appeared to him "that the staff of the committee approached the problem of pricing too much on the basis of ordinary subcontracting of standard items by a broker." He also spoke in favor of the systems manager concept, and "the savings to the governmen that were realized."

Ervin defended the high profits mentioned in the report, saying "in the very nature of things it is inevitable that contractors and subcontractors engaged in the development of missiles and other weapons for national defense for a single customer under these circumstances and hazards and uncertainties should receive profits substantially in excess of those who produce stable goods for sale to the general public."

Members of the subcommittee approving the report were Chairman John L. McClellan (D-Ark.) and Sens. Henry M. Jackson (D-Wash.), Edmund S. Muskie (D-Me.), Thomas J. McIntyre (D-N.H.), Daniel B. Brewster (D-Md.), Karl E. Mundt (R-S.D.), and Jacob K. Javits (R-N.Y.).

The three missile systems chosen for extensive probing were *Nike, Bomarc* and *Atlas* (although the report made no specific recommendations on *Atlas*). Hearings were held during April and May, 1962, and the 155-page report has been two years in the making.

- **Nike**—The investigating group attacked the weapons system manager method of procurement, the absence of competition, and the Armed Services Procurement Regulations (ASPR).

Because the Army itself lacks skills, the subcommittee said, it has "abandoned" to industry the management as well as the development and production of weapons of a new or advanced concept. This led to contractors making decisions which should have been the Army's.

Once the contractor is selected, no competition is introduced into the system, and this "removes normal safeguards against large profits and weakens the Government's negotiating position."

Also, while the ASPR system "may be equitable for a vast number of procurements where the contractor has been competitively selected, it leaves much to be desired in the negotiation of a contract for a new weapon system where it is known by the negotiators that a substantial portion of the program will be subcontracted."

The *Nike* program, the report said, is "an example of advantages accruing to the contractor in both unreasonably high profits and unwarranted control over the program." The subcommittee concluded that the 19-year relationship with Western Electric Co. was retained because: 1) inadequacy of Army technical and administrative forces and inability to manage missile systems procurement "left them unable to fill the breach of any threatened Western Electric pullout"; 2) meetings between Western Electric officials and civilians at the Secretary of the Army level "hamstrung" Army procurement officers from accomplishing a "breakout" or direct procurement of subsystems from the producers; 3) vesting of program management in Western Electric enabled them to refuse breakout; and 4) "Western Electric resisted any attempt by the Government to break out and thus eliminate pyramided profits to be paid to the prime contractor and, in some instances, to middlemen like Douglas (Aircraft Co.)."

In a statement accompanying the report, Chairman McClellan said that Western Electric's in-house effort was $399 million, with $1 billion either subcontracted or purchased. "Western Electric, however, took a profit of $112.5 million, which represents a profit of 7.9% of the total costs of the program." However, he added, compared with what Western Electric actually performed, the profit percentage is 31.3%.

Douglas Aircraft Co., performing $103 million of the tasks in a subcontract, farmed out $496 million. Its profit related to its own in-house effort was 44.3%, the report charged.

The committee also said that the government paid excessive profits on the *Nike* system because of inept Army administration of the program. "Top technical personnel at Redstone Missile Command admit they did not have the capacity to manage the *Nike* system during the period 1951-61; they do not have it now; and they will not have it if and when the . . . *Nike* antimissile missile program comes along."

- **Bomarc**—The subcommittee said the Air Force had prematurely forced Boeing into an incentive-type contract which Boeing initially opposed.

It charged that excessive profits were realized because cost underruns were attributable to "overestimation rather than Boeing efficiency."

The subcommittee hastened to add that it was not in favor of cost-plus-fixed-fee contracts, but that recently promulgated ASPR's calling for early use of incentive contracts hinged to timeliness and quality, as well as cost, are "a step in the right direction." ■

Checking compatibility . . .

First Gemini Mission Is Key To Initial Two-Man Flight This Year

NASA also discloses decision to try in future missions to achieve direct rendezvous—a possible space 'first'

by Hal Taylor

SPACE AGENCY officials have announced initiation of the first phase of Project *Gemini* and revealed plans for direct rendezvous and other tricky docking operations for the two-man spaceflight series.

NASA scheduled the first, unmanned, flight for April 7, but slippage to April 14 was considered possible. The orbital flight from Cape Kennedy is the first step in the drive to orbit two men by the end of this year.

At the same time, officials said plans now call for attempting later in the program direct rendezvous—launching a vehicle from Earth to dock with another shortly after orbital insertion.

This eliminates the need for the so-called "chasing" orbit, in which one vehicle slowly overtakes another. It also involves complicated guidance and launch problems, and has obvious implications for possible future anti-satellite weapons that would require a similar rendezvous capability.

If achieved early enough, direct rendezvous could be a Space-Age first for the United States. The Soviet Union attempted the same mission on Jan. 16, 1963, but missed by three miles.

Other rendezvous exercises which the space agency wants to perform in later flights include counting down of two vehicles simultaneously and launching them in close proximity to each other, docking tests duplicating the type envisioned for the *Apollo* lunar flights, and tests to simulate malfunctions during which the two vehicles might be coupled without the use of radar.

- **Progression**—The first flight in the series, however, will be mainly a spacecraft and launch vehicle compatibility check.

If unsuccessful, it will be followed by a full-system ballistic flight in midsummer and then the first manned *Gemini* flight late this year.

If unsuccessful, the first flight will be repeated, using a backup spacecraft, probably near mid-year.

Gemini missions begin against the background of a nine-month slippage in schedule and a total cost almost three times higher than the early estimates. When the program was announced in 1962, the first launch was scheduled for mid-1963 and the cost was estimated at about $400 million. Total cost is now set at $1.2 billion, with $185.2 million required to complete the program in Fiscal Year 1966.

The project—with primary emphasis on its manned orbital rendezvous and long-duration missions—now calls for 12 flights. The first manned flight will be a simple three orbits. The second flight will extend to four days, and the third to seven days. Rendezvous tests will begin with the sixth mission; then the space agency plans to alternate the long-duration missions of up to two weeks with the rendezvous docking experiments.

Three flights are scheduled this year. Four are planned for 1965 and five for 1966.

- **No recovery**—The upcoming unmanned flight, designated *Gemini Titan I (GT-I),* will be launched from Complex 19 at Cape Kennedy at an azimuth of 72 degrees. The McDonnell Aircraft Corp. *Gemini* capsule and the second stage of the Martin *Titan II* launch vehicle will be placed together into an elliptical orbit with an apogee of about 183 miles and a perigee of about 99 miles.

No recovery is planned. Orbital lifetime is expected to range from hours to weeks.

The orbiting combination will be tracked by NASA's worldwide network of tracking stations until the electrical power on the spacecraft is depleted about the end of the first orbit.

The *GT-I* measures 108 ft. in height. The first stage is 70 ft., including engines. The second stage is 19 ft. high. The spacecraft and adapter add another 19 ft.

The *Titan II Gemini* launch vehicle (GLV) first and second stages are 120 in. in diameter. Diameter of the adapter is 120 in. at the base and 90 in at the top. The spacecraft has a 90-in. base diameter and a 31-in. diameter at the top.

Launch weight of the vehicle and spacecraft is 300,000 lbs. The GLV weighs approximately 293,000 lbs., and

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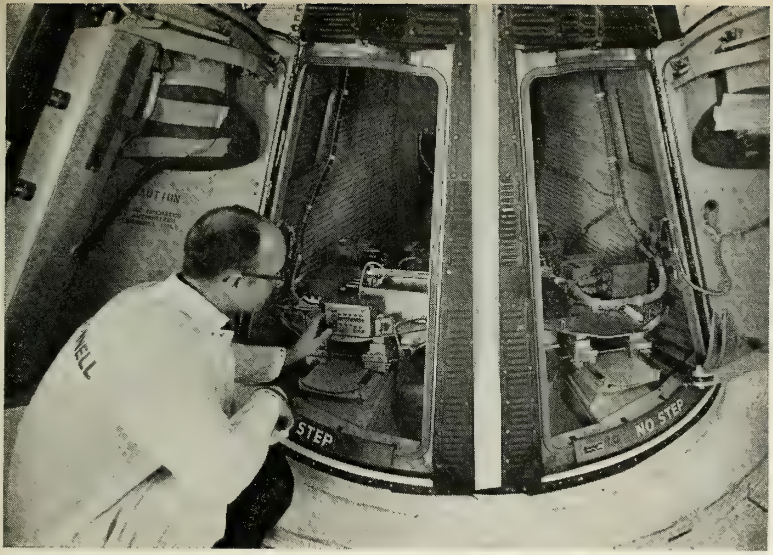
$33 Million of NAS

NASA has earmarked at least $33 million of its Fiscal Year 1965 budget request for development of alternate systems for Project *Apollo.*

Another $15.9 million will be spent both in-house and with industry to improve various systems for the launch vehicles and spacecraft for the U.S. manned lunar landing program.

The funding breakdown was given to the House Space Committee by Dr. George E. Mueller, NASA Associate Administrator for Manned Space Flight.



McDONNELL technician checks equipment that will monitor first Gemini flight.

the spacecraft and adapter weigh approximately 7,000 lbs.

- **Spacecraft**—The *Gemini* spacecraft is similar to the basic shape of the earlier one-man *Mercury* spacecraft. It is, however, 15½ in. wider in diameter at the base and 12½ in. longer, and it contains 50% more volume than *Mercury.*

Gemini consists of two major assemblies, a re-entry module and an adapter section.

The re-entry module includes a nose fairing, a rendezvous and recovery section shaped like a truncated cone, a re-entry control section and the cabin.

The latter is located between the re-entry control section and the adapter. It is covered by heat-resistant shingles and has pressure bulkheads at each end. There are two hatches on top of the cabin to provide for entry and egress of astronauts.

Five separate equipment bays, outside pressure areas, are designed for mounting equipment which does not require pressurization and for components having self-contained pressurization.

The adapter section for *GT-1* will be used simply to join the spacecraft to the launch vehicle. In later flights, it will contain equipment and will be jettisoned prior to re-entry.

- **Instrumentation**—*GT-1* will contain two instrumentation pallets which replace the crew couches used in manned missions. Pressure transducers, temperature sensors and accelerometers will be mounted on the pallets so that flight data can be telemetered to the ground stations.

A total of 104 measurements—covering temperature, acceleration and pressure—will be telemetered during the flight. Instrumentation on Pallet 1 weighs 212 lbs.; on Pallet 2, 188 lbs. In addition, 892 lbs. of ballast is mounted on the pallets.

Other spacecraft instrumentation includes environmental control, cooling, communications and electrical systems.

The environmental control system will be used to establish and maintain a differential pressure between the interior of the cabin and outside atmosphere.

The cooling system consists of a series of coldplates installed on the instrumentation pallets in the cabin. Equipment requiring cooling is mounted directly on the coldplates.

The communications system includes a C-band radar beacon, phase shifter, dc-ac inverter, three C-band antennas, three telemetry transmitters and a UHF antenna. The system will serve as an instrumentation signal and spacecraft position link between the spacecraft and the ground.

The electrical system basically is one main battery, several control relays and interconnecting wiring. It supplies power for all instrumentation and communications components.

- **Goals**—Some primary objectives of *GT-1* are to:

—Demonstrate structural compatibility of spacecraft and launch vehicle from lift-off through orbital insertion.

—Determine heating conditions during launch on both spacecraft and launch vehicle.

—Demonstrate launch vehicle performance and qualify the vehicle subsystems for future flights.

—Demonstrate structural integrity of spacecraft from launch through orbital insertion.

—Demonstrate ability of the launch vehicle and ground guidance systems to accurately achieve orbital insertion conditions. ■

Y '65 Budget for Apollo Backups

Some $19 million of the funds allotted for backup systems will be spent in the spacecraft area. This includes an *Apollo* afterbody heat shield, a manned space vehicle guidance computer, communications and telemetry system development, electrical power systems and Earth landing systems.

Alternate development in the launch vehicle area includes cryogenic systems, reduction of fuel and oxidizer leakage, fuel tank bulkhead, alternate guidance components, large structures fastening, welding and forming development, launch support and checkout. A total of $10 million will be spent on those systems.

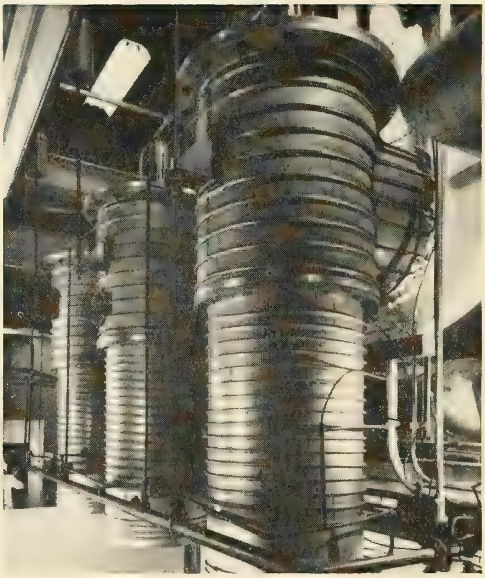
A $4-million alternate-development budget for propulsion also has been requested. More funding will be given to sensing and abort implementation systems, ignition systems, S-IC stage retromotors, landing impact attenutation systems, fuel tank pressurization, a radiation-cooled reaction-control engine and an ablatively cooled reaction-control engine.

Funds for improving various systems include $1.2 million for spacecraft, $3 million for launch vehicles, $8.2 million for propulsion and $3.5 million for launch operations.

Other potential backup systems have been recommended by various NASA field centers and are currently under consideration by Manned Space Flight officials.

Final decision is not expected, however, until Congress completes action on the FY '65 budget request and officials have a better idea of how much money will be available.

News Briefs



Silicones help simulate space . . .

Fairchild Camera and Instrument Corporation's Defense Products Division has a 3,000 cubic foot test chamber at Syosset, Long Island. It is used to simulate the environmental pressure at altitudes of 380 miles . . . vacua in the range of 4×10^{-9} mm Hg.

Dow Corning® diffusion pump fluid is used in the six 32-inch diffusion pumps to achieve the desired test chamber pressure level. Silicone diffusion pump fluid offers superior resistance to oxidation; will not decompose or lose pumping properties; recovers 15 to 20 times faster than conventional fluids after exposure to air; eliminates the need to cool pumps before releasing vacuum; is chemically inert.

Dow Corning also produces a line of coolants for space chambers and other test facilities. Some resist radiation.

CIRCLE No. 22 ON READER SERVICE CARD

AEROSPACE NEWS from Dow Corning

New silicone ablative material bonds in place... is lightweight... flexible

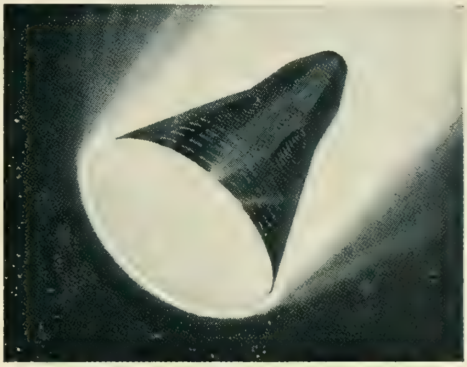
DOW CORNING® 325 Ablative Material has been selected by McDonnell Aircraft Corporation for the heat shield on NASA's Gemini spacecraft. There are numerous reasons, including:

Lightweight — for equivalent volume it weighs about one half as much as rigid reinforced plastics used for ablative applications.

Flexible — supplied as a pourable liquid, Dow Corning 325 ablative material can be cast or molded . . . cures to a rubbery solid. Thermally induced stresses which tend to destroy rigid materials are absorbed by the elasticity of this new material.

Bonds — Dow Corning 325 ablative material will bond to many metals, plastics and ceramics . . . has excellent shear strength. Cured pieces can be bonded to substrates with adhesives. New Dow Corning 325 ablative material will bond to already cured sections of the same material, and to most materials used for honeycomb.

Swells — when exposed to heat fluxes that cause it to char, Dow Corning 325 ablative material swells, thus increasing the effective thickness of the shield.



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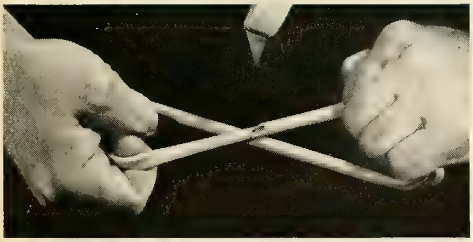


High strength, tear resistant silicone rubber . . .

Silastic® 950U rubber is a silicone stock designed for applications in aircraft, space vehicles and ground support equipment. This 50-durometer silicone rubber provides high tensile strength, 1400 psi minimum; tear strength of 175 psi or better; a brittle point of −178 F; good heat stability at 500 F. This stock shows all the properties typical of silicone rubber and is designed to meet the requirements of the following military and commercial specifications: MIL-R-5847D, Class III, Grade 50; MIL-STD 417, TA 510 and TA 512; AMS 3345; and SAE-ASTM TA 510 and TA 512. Parts made from this material are available from many companies fabricating rubber parts to meet the specialized requirements of aerospace applications.

CIRCLE No. 23 ON READER SERVICE CARD

For further information about materials mentioned here . . . or our capability to provide you with tailor-made materials designed specifically to meet your requirements, write Dept. 6204, or call Aerospace Materials Department, Dow Corning, Midland, Mich.

Dow Corning

Returning at 25,000 mph . . .

Project Fire Shot Seeks Re-entry Data for Apollo

NASA this week will make an attempt to gather data on high-speed re-entry conditions vital to the U.S. manned lunar landing program.

This information will be gathered during the flight of the Project *Fire* spacecraft.

The heavily instrumented 200-lb. payload—scheduled for launch from Cape Kennedy no earlier than April 6—will make direct measurements of re-entry heat at speeds of about 25,000 miles per hour, slightly higher than the anticipated velocity of the *Apollo* spacecraft when it re-enters the Earth's atmosphere from the Moon.

Ballistic flight of the Project *Fire* spacecraft, to be launched by an *Atlas D* booster, is expected to last 32 minutes. This includes a 21-minute coast period during which the vehicle will be oriented in the correct entry attitude.

At 26 minutes after lift-off, the Antares II solid rocket will be fired to bring the spacecraft back to Earth at the desired velocity. Impact will be some 5,000 miles downrange in the South Atlantic.

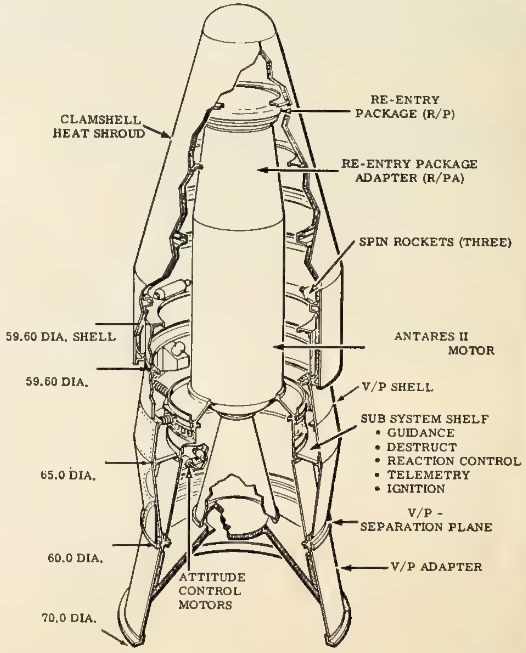
The spacecraft will reach an apogee of 500 miles during the flight. The data on re-entry conditions will be gathered by radiometers that will measure radiation and 250 thermocouples to measure heating. It will be sent back to Earth by on-board transmitters.

- **Window narrows**—Launch window is chosen to provide total darkness at 400,000 ft. in the re-entry area. On April 6, the launch window is between 3:33 p.m. and 9:03 p.m. EST. By mid-April, the window begins to diminish rapidly; it closes entirely by April 21.

The spacecraft consists of the *Atlas D* launch vehicle, built by General Dynamics/Astronautics; the re-entry package, developed by Republic Aviation Corp.; and the velocity package, built by Ling-Temco-Vought, Inc. The Antares II was produced by Hercules Powder Co.

GDA, in addition to launch vehicle responsibility, also was in charge of overall integration of all subsystems and systems involved in Project *Fire*.

The instrumented re-entry package is a blunt-faced vehicle with a conical afterbody, 26 in. in diameter and 21 in. long.



PROJECT Fire spacecraft and velocity package adapter.

PRELIMINARY DESIGN ENGINEERS FOR ADVANCED MISSILES AND SPACECRAFT

Unusually interesting positions exist for qualified engineers who can perform on a variety of high interest aerospace vehicle studies and who have a capability for proposal preparation.

Responsibilities for the area will include: Preparation of preliminary concepts, structural and component installation designs for proposals and advanced studies in missiles and spacecraft programs; performance of weight, balance and inertia studies; providing written proposal materials.

Experience in aircraft or missile structural design is essential, with a working knowledge of preliminary stress analysis, effects of extreme environment, and applicable materials. Applicants should be generally familiar with various vehicle subsystems, particularly in the propulsion and attitude control areas.

Qualifications should include a B.S. degree from an accredited university with 5 to 10 years applicable experience.

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The first, third and fifth layers are beryllium calorimeters instrumented to provide temperature readings from which the total heating rates will be determined. The second, fourth and sixth layers are heat shields. All but the last two layers will be burned away or jettisoned during the 45-second flight through the high re-entry heating period.

● **Re-entry procedure**—Choice of the layer design was dictated by the fact that beryllium will survive only seconds of intense re-entry heat. As a result, a series of calorimeters will be

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The Project *Fire* flight will also mark the first use of a NASA tracking telespectrograph on Ascension Island. It will be used to take a spectrographic record of the re-entry. ■

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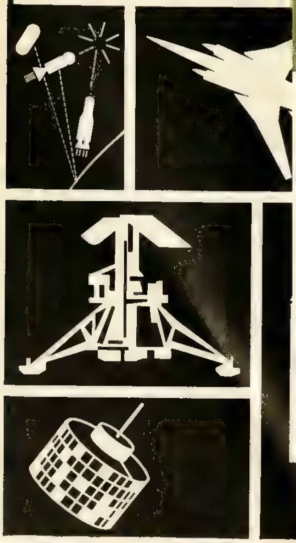

Returning at 25,000 mph . . .

Project Fire Shot Seeks Re-entry Data for Apollo

NASA this week will make an attempt to gather data on high-speed re-entry conditions vital to the U.S. manned lunar landing program.

This information will be gathered

area. On April 6, the launch window is between 3:33 p.m. and 9:03 p.m. EST. By mid-April, the window begins to diminish rapidly; it closes entirely by April 21

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to Earth by on-board transmitters.

• **Window narrows**—Launch window is chosen to provide total darkness at 400,000 ft. in the re-entry

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V/P ADAPTER

PROJECT Fire spacecraft and velocity package adapter.

In the blunt end of the re-entry package are three beryllium calorimeters (devices for measuring absorbed heat) interleaved with three phenolic-asbestos ablative heat-protection layers.

The first, third and fifth layers are beryllium calorimeters instrumented to provide temperature readings from which the total heating rates will be determined. The second, fourth and sixth layers are heat shields. All but the last two layers will be burned away or jettisoned during the 45-second flight through the high re-entry heating period.

- **Re-entry procedure**—Choice of the layer design was dictated by the fact that beryllium will survive only seconds of intense re-entry heat. As a result, a series of calorimeters will be used, one during the earliest portion of the re-entry, one when heating rises to a peak, and the third near the end of the heating period. Two of the ablative protection layers will be jettisoned at programmed times to expose a fresh calorimeter to the hot-gas region.

Within the re-entry package are three radiometers. Two will measure total radiant energy; the third is a combination total and spectral radiometer. Radiant energy will be admitted to the instruments through three fused quartz windows. One is located at the center of the forward face, in what scientists call the stagnation region, the second near the corner of the front face, and the third on the conical afterbody.

The combination total and spectral radiometer is designed to measure the radiant energy in such a way that experimenters can gather information on the chemical composition of the gases in the radiant region. It will scan radiation at the stagnation point over a wavelength range from 2,000 to 6,000 Angstrom units.

The conical afterbody is built of sheet aluminum and glass fiber covered with a phenolic asbestos laminate. In addition to the primary Project *Fire* instruments, it contains: data acquisition and processing electronics; two solid-state telemetry transmitters; a delayed data system that tape-records research measurements during the radio blackout period for transmission 45 seconds later; a C-band beacon for radar tracking; an attitude-sensing system consisting of three rate gyros and five linear accelerometers; pressure sensors; an electronic device attached to the realtime telemetry transmitter to gather information on signal attenuation caused by the plasma sheath; a time-code generator to indicate elapsed time starting from liftoff; and a cooling system.

The Project *Fire* flight will also mark the first use of a NASA tracking telespectrograph on Ascension Island. It will be used to take a spectrographic record of the re-entry. ■

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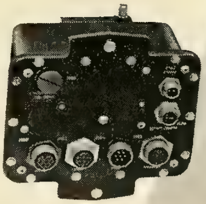
RADIO CONTROL SET

Command flight control equipment by RS Electronics is setting new reliability standards. Remote control of the Navy's KD2R-5 drone shown here is achieved with RSE's Radio Receiving-Control Set which bears the MIL designation AN/ARW-79.

This set consists of an RSE Command Receiver Model 2624AT, proportional Decoder Model 1301A and Model 1805W Accessory Decoder if required.

These components comprise a single, compact airborne package designed and built for Northrop Corporation under U.S. Navy contract. This equipment combines solid state reliability with the packaging advantages of specially designed printed circuit boards.



Model 2624AT/1301A

Operated in conjunction with an airborne gyro to provide automatic flight stabilization, the unit will also control line-of-sight flights without the gyro. The basic package weighs only 4 lbs. 13 oz. and measures $7\frac{5}{8}$" high x $7\frac{1}{4}$" wide x $5\frac{1}{4}$" deep.

In addition, RS Electronics can provide complete communications links for the remote control of pilotless aircraft and missiles. A typical link would consist of a coder, transmitter, airborne receiver and decoder.

For complete specifications on this Radio Control Set or other RSE equipment to satisfy special requirements, write to:

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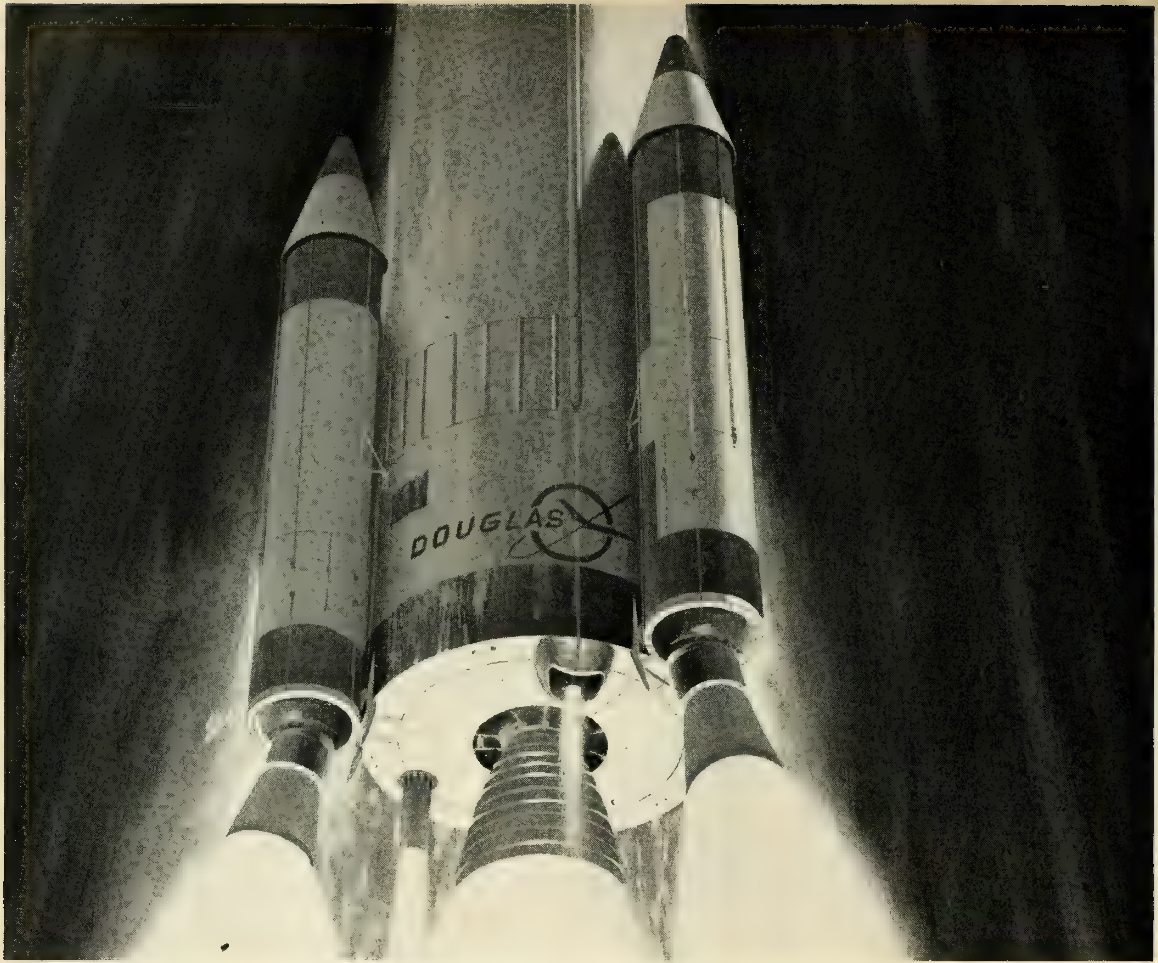

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MATERIALS

Oxidation-Resistant Graphite Perfected

Additives of zirconium, boron and silicone to graphite result in a composite with improved strength, hardness and oxidation resistance, report scientists at Union Carbide Corp.'s Carbon Products Div. Developed under a contract from the Air Force Materials Lab., the composites provide a protective coating through oxidation of the additives at the troublesome temperature levels where the graphite is prone to destructive oxidation. The coatings are self-healing and even re-form in place after punctures are made by particle impacts. The additives, in the form of powdered zirconium diboride and silicon, are blended with graphite particles and a binder. Impregnated shapes are formed at 4,000 psi and 4,100° F. Composite density is above 3 g/cc and flexural strengths up to 25,000 psi have been measured at 3,600° F.

Sodium-Cooled Nozzles Pass 6,200° F.

An approach to high-pressure, high-temperature nozzle assemblies using sodium as a coolant is now past the demonstration phase at Allegany Ballistics Lab. Hercules Powder Co. engineers ran a sodium-jacketed nozzle assembly for 38 seconds in a firing test with chamber pressures above 290 psi with exhaust gas temperatures above 6,200° F. The sodium method extends the ability of current nozzle materials into the near-7,000° F. range—the area where high energy, high acceleration propellants function. The nozzle assembly was described as flightweight by Hercules experts and an advanced double-base propellant was used in the test at the Hercules-operated Naval facility.

PROPULSION

Bell Fires High Pressure F/H Engine

A fluorine-hydrogen propellant combination exceeded 95% of the theoretically possible performance in a recent test firing by Textron's Bell Aerosystems Co. The engine generated 40,000 lbs. rated altitude thrust with a chamber pressure in the 500 psia range. The high pressure essentially means the engine is attaining high performance with minimum weight. Combustion was described as smooth and stable in the company-sponsored test firing. The test is the latest development in over eight years of Bell-supported fluorine propellant research and development.

Aerojet's Big Solid Plant On Stream

Live propellant flowed from the continuous mix segment of Aerojet-General Corp.'s Big Solid Booster plant in Dade County, Fla., during initial shakedown operations. The propellant processing step is the first leg of checking out the new plant. Subscale motors will be loaded next month for test firings at the firm's Sacramento, Calif., facilities. The plant will also use batch mixing equipment in preparing the 260-in.-dia. solid rockets for test firing next year (M/R, Dec. 2, 1963, p. 29). The massive motor case program at Sun Shipbuilding and Dry Dock Co., Philadelphia, is nearing the tooling completion phase. Two of the 18% nickel-steel cases are being fabricated by Sun under contract to Aerojet for delivery in the fall of 1964 under the Air Force/NASA Large Solid Demonstration Program.

Titan III Thrust Termination Tested

A test of the thrust termination and command destruct systems used on the *Titan III-C* booster rockets was successfully conducted at Edwards AFB, Calif., and, according to the Air Force, "confirmed operation of both systems." Two of the 120-in. solid motor segments were fired for 10 seconds. Thrust was terminated by blowing two ports in the forward closure, releasing the internal pressure generated by the burning propellant. A destruct signal detonated a strip of primacord which ruptured the rocket case.

ELECTRONICS

Pinhead-Size Diodes Built

Hughes Aircraft Co. scientists now claim the ultimate in discrete diodes—a glass-encapsulated element measuring 0.060 in. in diameter. The junction itself measures 0.020 in. in width (or about the size of a typed period). Employing dual glass seals, the diode—called Microglass—represents the connecting link in microminiaturization between miniature diodes and integrated circuits, according to Hughes. Now in production, Hughes says it is aiming for a production capacity of over one million diodes per week.

Incoherent-Light Tracker in Development

A high resolution, microwave-modulated, optical Doppler radar using an incoherent light source is under development at the Hallicrafters Co. in Chicago. Scientists there feel this is the first practical employment of high-intensity light for measuring precise target velocity in space. Also, they point out, the use of incoherent light bypasses many of the problems inherent in the use of a laser beam (scattering, in particular). The Hallicrafters approach employs the dynamic crossed-field electron multiplier invented at the University of Illinois. The system reportedly will provide very high signal sensitivity and high amplification.

ASTRONAUTICS

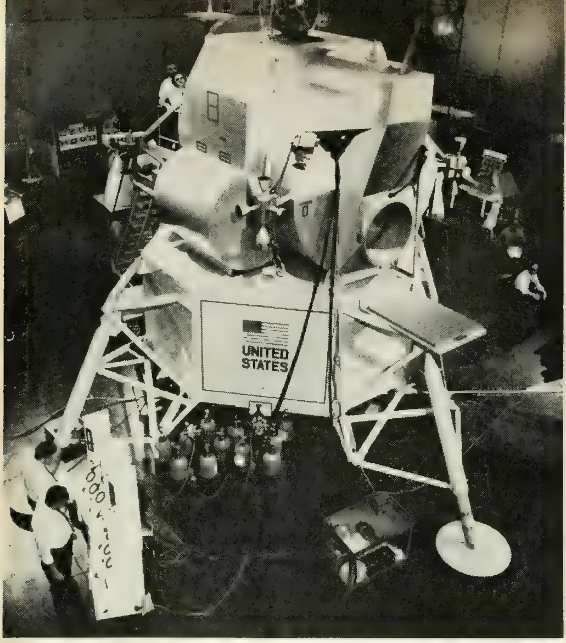
Steerable Chute Proposed For Gemini

A glide ratio of better than 2:1 was shown by a steerable parachute in wind-tunnel tests at NASA's Ames Research Center. Developer of the parachute, Northrop Ventura, Newbury Park, Calif., is proposing it to NASA for later phases of the *Gemini* program. Looking quite conventional, the steerable parachute has a leading edge stiffened with fabric. When two gores are lifted on the trailing edge, they give an outflow of air that makes the chute go forward.

SPACE MEDICINE

Dehydration a Factor In Blood Pooling

Researchers at the Lankenau Hospital, Philadelphia, conclude that the blood pooling problem, or "orthostatic hypotension," suffered by both astronauts Walter Schirra and Gordon Cooper, could be due as much to dehydration as to weightlessness. The subject studied showed a marked increase in the effect after a period of bed rests when he was also dehydrated.



ASTRONAUT descends into LEM TM-1 through overhead hatch. Forward docking hatch is visible, as is rendezvous radar.

LEM Design Is Nearly Frozen

Review of test model establishes final configuration before building metal mockup

Bethpage, N.Y.—The first of nine Lunar Excursion Module test articles (LTA's) for ground testing is now scheduled for completion here in one year.

A NASA/Grumman Aircraft Engineering Corp. review of the full-scale wood-and-metal TM-1 LEM test model ended March 27 at a four-day round of meetings. The test model had been completed earlier in March.

Objective of the review was to establish a design freeze on LEM to allow construction of the all-metal M-5 LEM mockup, which will contain all equipment details of the final LEM design. The M-5, which next fall will undergo a similar review to that conducted on TM-1, will be the last LEM model built before completion of the first LTA.

The TM-1, reflecting what is expected to be the last major configuration change in LEM (the removal of two of the four propellant tanks in the ascent stage and the introduction of a stand-up astronaut-restraint system for the cockpit—M/R, Feb. 10, p. 15) is now the representative vehicle upon which final detail design will proceed. TM-1 also reflects the new LEM triangular window design, which replaces the four windows of much larger area in earlier mockups.

• **Scope of review**—The review was aimed at pinning down some 30 different areas of LEM design. Key items included: location and shape of display panels; display arrangement; cockpit arrangement; crew support; portable back-pack location, donning, and recharging positions; waste-management equipment location; ingress and egress procedures; zero-g restraints; environmental control system equipment locations; antenna locations; scientific equipment bay descent stage location; docking drogue storage; and landing gear design.

Though the review was aimed at freezing details in these areas, certain evaluations will continue to get particular attention—e.g. ingress, egress, and cockpit operating procedures for space-suited astronauts. Astronauts are expected to spend time at Grumman in the next few months ironing out these questions.

Use of a rope suspended from the module is being demonstrated by space-suited astronauts at Bethpage, and the technique may be included in operating procedures as an alternate or backup to ladder exit and entry. Engineers here point out that it would cut weight, cannot be damaged in landing, and will always hang vertically when deployed, eliminating the risks of ladder use if the vehicle is tilting or damaged in landing.

Grumman engineers will also now begin to run antenna pattern tests on another LEM mock-up, a screen model built for this purpose, based upon the antenna locations of the TM-1.

In this configuration, the X-band rendezvous radar is mounted on top and forward on the vehicle, the steerable S-band communications antenna is on top and aft, and two VHF antennas are mounted high on the vehicle and diagonally opposite.

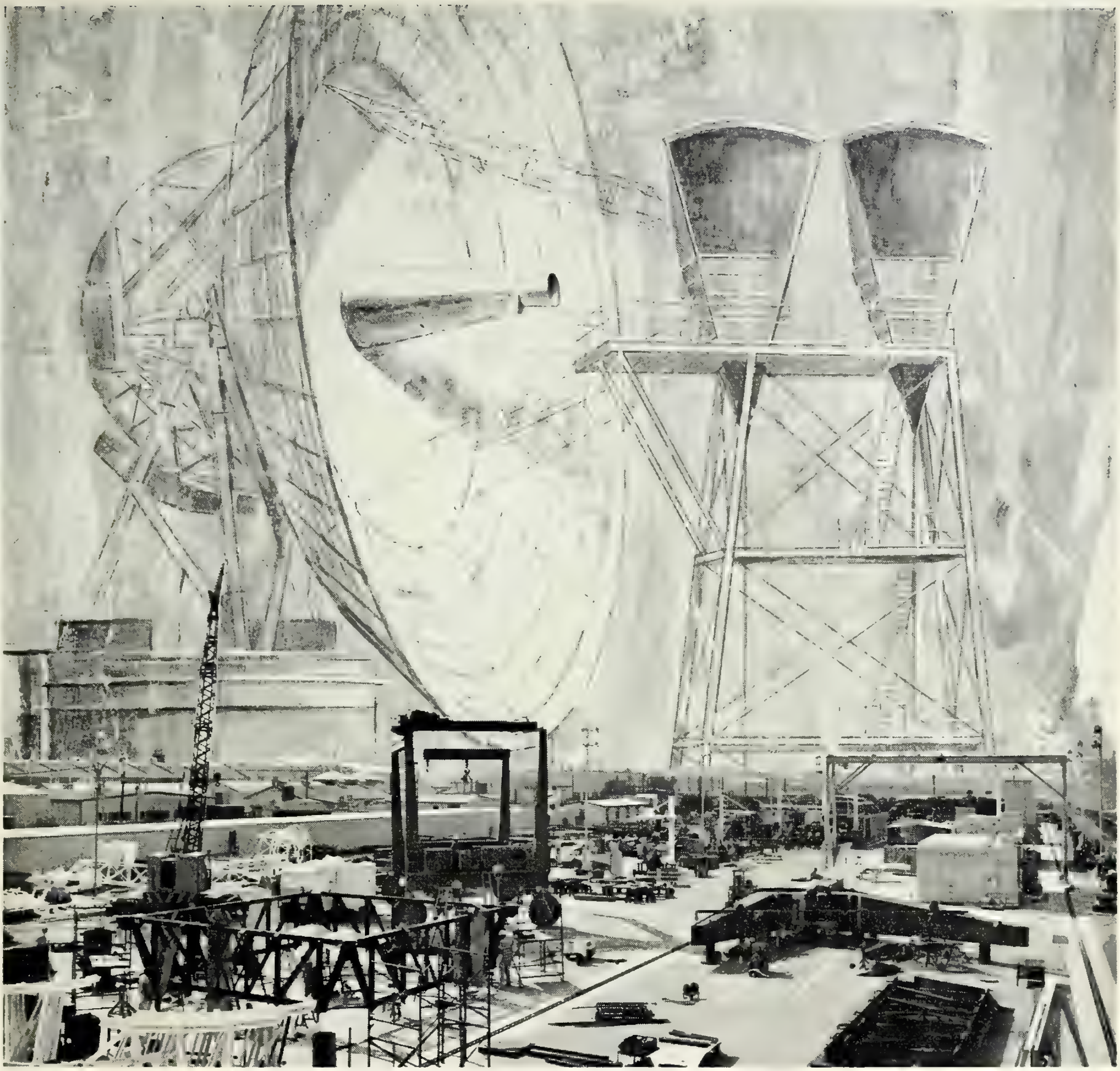
The X-band landing radar is now mounted on the aft right hand quadrant of the descent stage, but engineers feel this location may still change.

• **Landing gear uncertainties**—Though the design of the LEM landing gear (M/R, July 15, p. 22) still suffers from lack of data from unmanned probes aimed at the lunar surface, both NASA and Grumman officials express confidence in what they classify as a highly conservative gear design to meet the most extreme conditions predicted on the basis of current knowledge.

If anything, they feel that any future changes in gear design may allow weight reductions, if successful probes indicate a less imposing surface than the current design anticipates. Reductions in landing gear weight could increase LEM's ability to lift some 100 lbs. of lunar samples off the surface.

The major design decision left in the program is the choice of the descent stage engine now in parallel development at North American Aviation's Rocketdyne Div., and the Space Technology Labs. A decision is expected before years's end, possibly in the fall. Project engineers report the choice will be difficult in that both engines show major advancements in throttleable systems.

The TM-1 descent stage (metal) is now being instrumented here and will undergo thermal environmental tests within the next few weeks. Altitude facilities for descent engine testing are being built at both contractor locations, and will reportedly be available in May. The Bell ascent stage for LEM is also now being instrumented in preparation for environmental tests this month at the Arnold Engineering Test Center, Tullahoma, Tenn. ■



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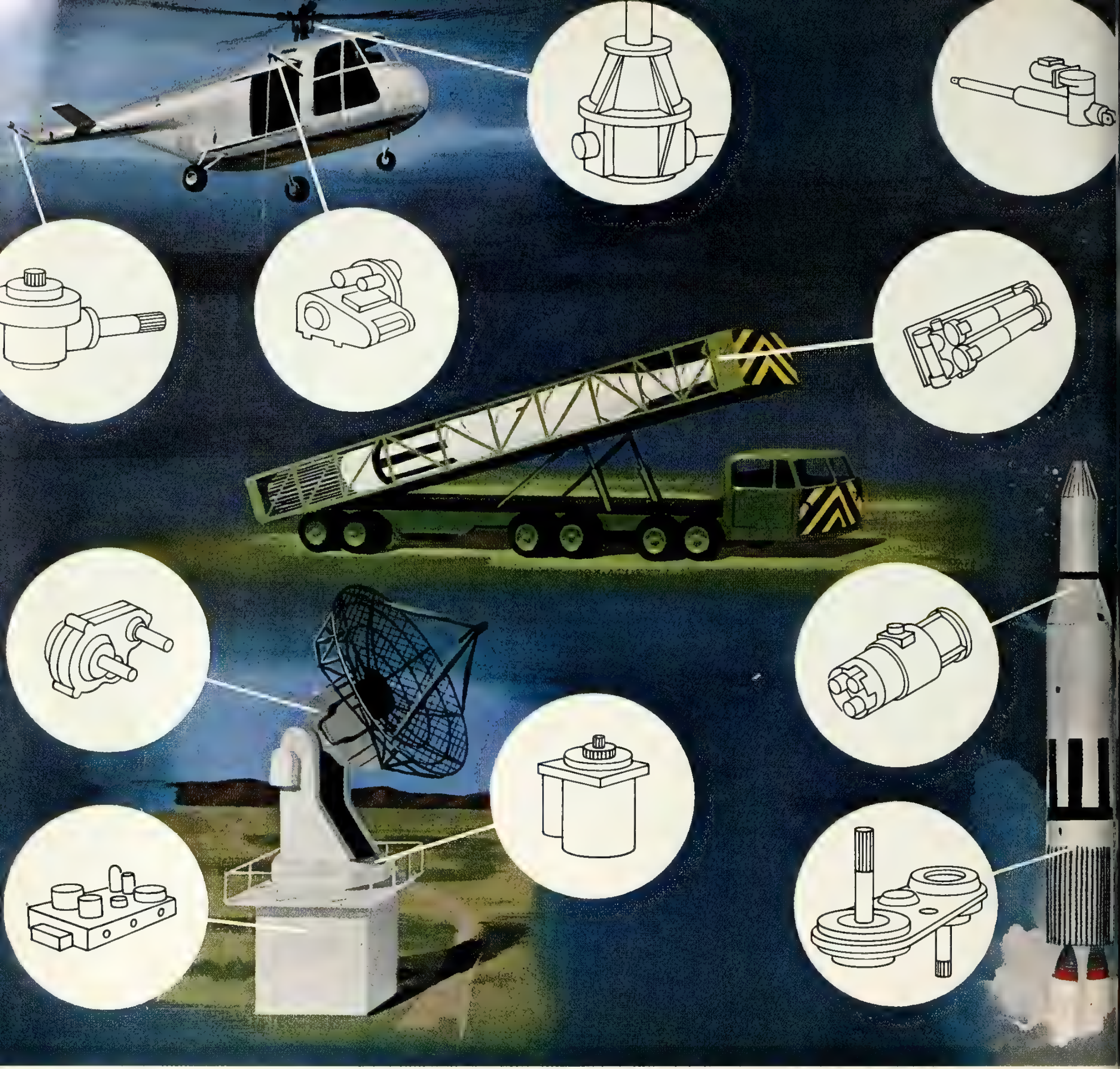

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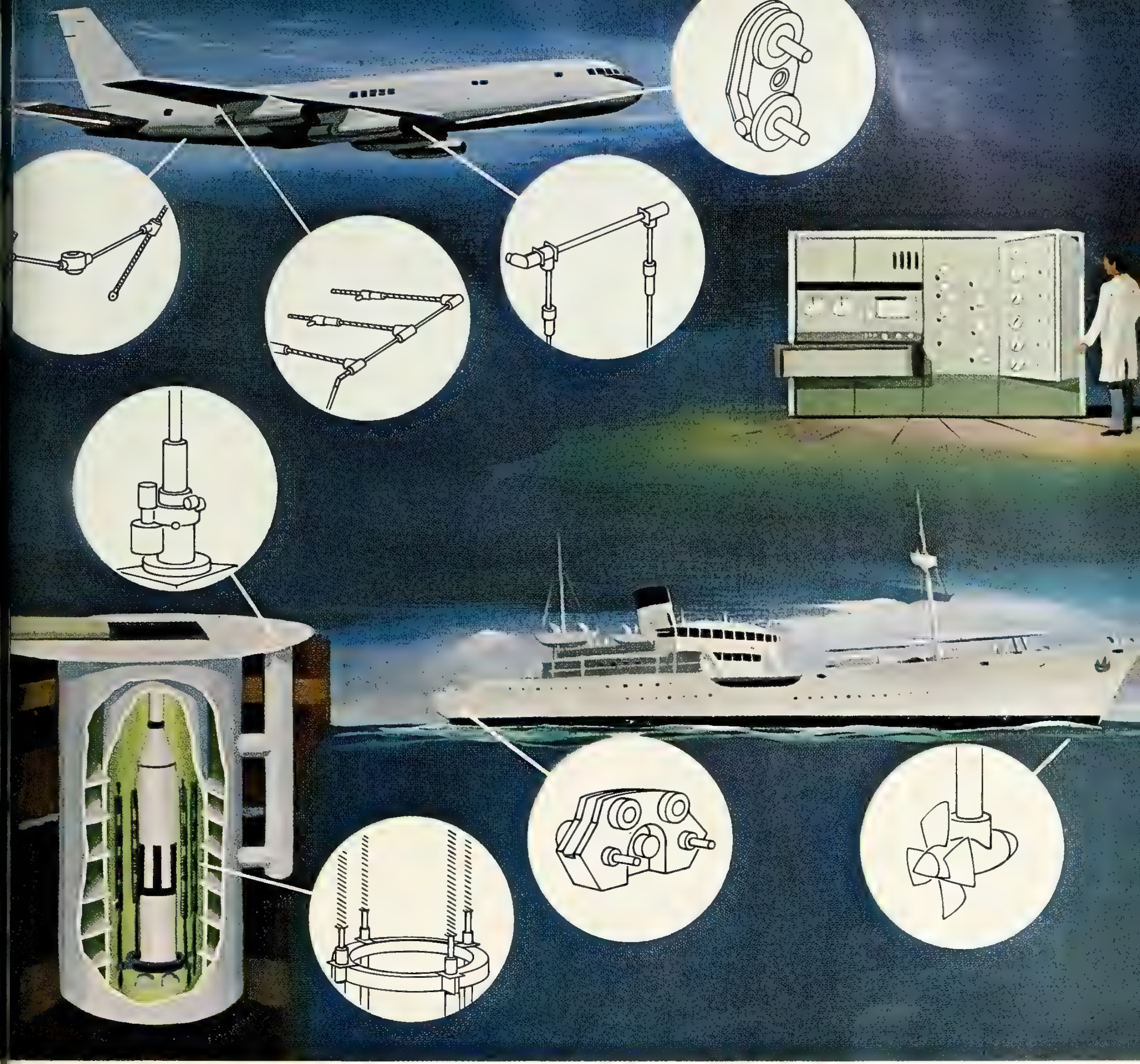

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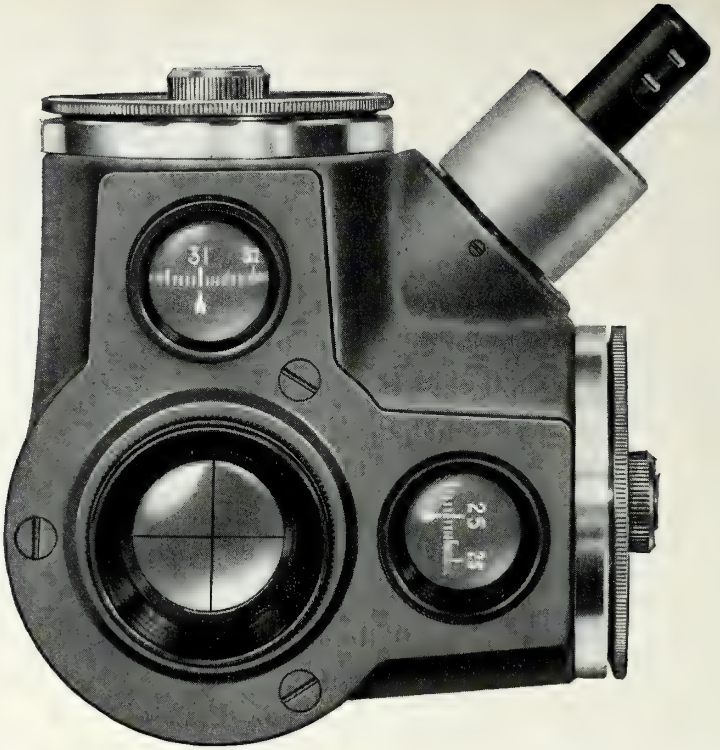

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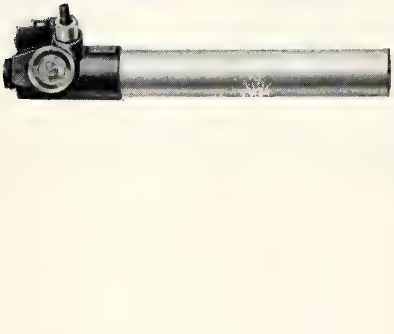

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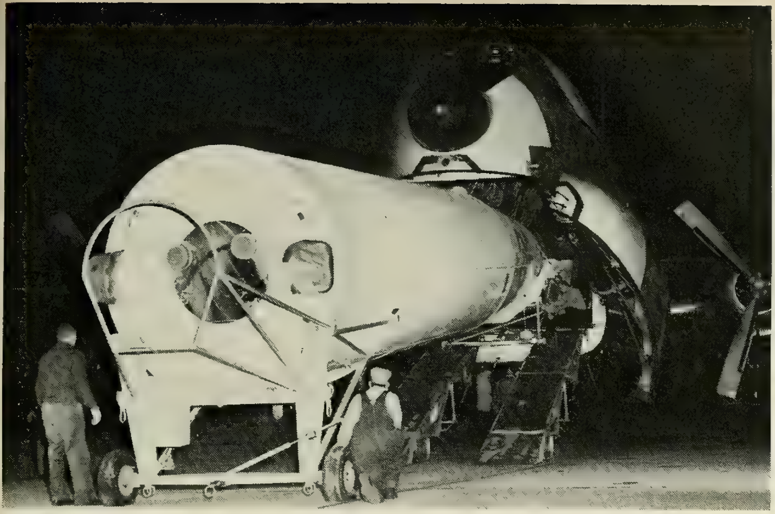
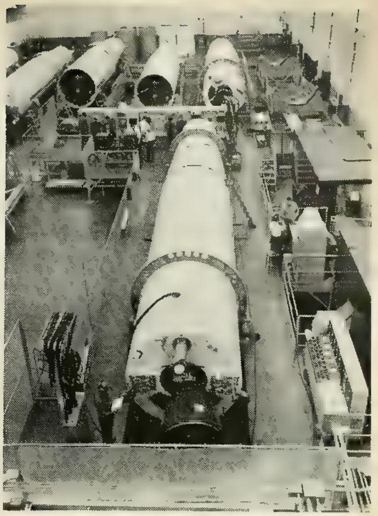


THOR still bearing RAF markings arrives at Douglas Tulsa Div. for conversion.



CONVERTED Thor at checkout stand.

Former RAF Thors Made into Boosters

Air Force says it's saving up to $150,000 per launch through first 'swords-into-plowshares' missile program at Douglas-Tulsa

by Willard E. Wilks

TULSA, OKLA.—The Air Force reports that it is saving $100,000-$150,000 per space launch by making launch boosters out of Douglas *Thors* that formerly saw service as operational missiles in Britain.

First converted *Thor* put to work was utilized in the initial *ASSET* (Aerothermodynamic/elastic Structural Systems Environmental Tests) launch on Sept. 18, 1963; the second *ASSET* firing on March 24 used a two-stage converted version. So far, more than 20 of the 64 missiles, including backup vehicles, put on operational duty in the United Kingdom beginning in early 1959 have been ordered converted in the LVIIB program at Douglas Aircraft Co.'s Tulsa Division.

AF Space Systems Division estimates that a converted booster costs up to $150,000 less than a new (SLVII) vehicle off Douglas's assembly line in Santa Monica, Calif. Under the Douglas contract, the old *Thors* are returned to "new" condition as boosters. "The only difference between these and new ones is use of the original Block I engines with 150,000 lbs. thrust," an SSD spokesman says.

Engines undergo complete overhaul by San Bernardino Air Materiel Area (SBAMA), some by North American Aviation's Rocketdyne division. All are hot-fired at Rocketdyne's Neosho plant before going in to the pipeline that returns them to Tulsa for reinstallation, not necessarily in the same vehicles from which they were removed. Block II engines would fit the converted vehicles, but the original engines are used to hold down cost.

Time also was a prime consideration in the Air Force decision to go ahead with the conversion program in December, 1962. "There were programs that couldn't wait, and this filled the gap," a spokesman said. *ASSET* was one such program. Most of the converted vehicles have been slated for classified programs.

Programmed lead time necessary for a converted booster is three to four months less than that for a new vehicle, which runs up to 18 months. Main factor in the time saving is the engine; overhaul is faster than waiting for a new one.

- **Heavy demand**—All of the former Royal Air Force missiles, less some fired in RAF combat training launches at Vandenberg AFB, are expected to be converted eventually. Meanwhile, the balance remains in storage at SBAMA.

"We are not ordering conversions until firm requirements for these returned missiles are specified," an officer said. "However, we have fairly firm requirements for all of them. We've just completed a study to determine their potential use, and the report shows there are twice as many requirements as there are available *Thor* missiles."

Air Force spokesmen, noting that the program is "the first swords-into-plowshares conversion involving missiles of this size," say phased-out *Atlas* missiles also are expected to be converted to launch vehicles at some future date.

"This program has proved that it is possible to take a complex vehicle that was designed as a weapon and convert it to peaceful uses at a substantial saving and without sacrificing reliability. We can expect that there will be more of this."

- **Flexibility afforded**—So far, none of the current group of converted *Thors* has been slated for use by NASA, which wouldn't be expected to order any unless confronted with a need to cut launch vehicle lead time.

Nevertheless, the LVIIB program

ENGINE reinstallation is completed following conversion.

permits some flexibility that helps both Air Force and NASA. SSD has no firm commitments to begin with for all vehicles undergoing conversion. It gets some indications from the Dept. of Defense or NASA as to requirements and given numbers of vehicles, but no certain information as to program configuration.

However, it can start conversion of a given missile into an LVIIB. Then, when it receives firm word as to requirement, it can divert from the Douglas assembly line an SLVII to NASA; the Air Force, which has programs that can use 150,000 lbs. of thrust, will take the LVIIB. NASA thus gets an SLVII that otherwise would go to the Air Force, and the Air Force gets an LVIIB faster.

NASA has used some of the *Thors* in an earlier batch returned from England. When the fifth SM-75 squadron scheduled to be sent to the United Kingdom was cancelled, NASA took the vehicles for its *Delta* programs; the first 12 NASA *Delta* vehicles used converted SM-75's.

• **Reliability upgraded**—The Tulsa Div., which currently has 22 of the SM-75 missiles in its plant, some still bearing RAF markings, converts the vehicles to a standard configuration—the LVIIB—which can be varied to meet different mission configurations ordered by SSD, including some requiring addition of a second stage.

With the exception of the Block I engine, the LVIIB vehicles are identical to the SLVII launch vehicles, SSD said.

"Reliability is upgraded from that of missile to launch vehicle, and they are required to meet the same reliability standard as the new SLVII vehicles coming off the Douglas assembly line," a spokesman said.

"Some components that are in the SM-75 can be retained. As many parts as possible are refurbished and go back into the vehicle. But those parts that are not common to the SLVII are replaced in order to bring what was a missile up to launch vehicle configuration. The main items not changed are the tanks, on which there are no modifications."

The LVIIB is equipped with the mechanical and electrical interface necessary to take an *Agena D* second-stage vehicle, although not all of the boosters are slated to use a second stage. It also is equipped with an on-board telemetry system, necessary in R&D work, which the SM-75 does not have. It can be equipped with an airborne guidance system if the using program requires it.

Also modified is the transition section to equip the vehicle with second-stage instead of warhead capability. All of these modifications make the LVIIB identical to the SLVII.

• **LVIIC's for ASSET**—The *ASSET* program is utilizing two converted *Thor* configurations. The LVIIB is converted to an LVIIC for both single-stage and two-stage *ASSET* flights. The LVIIC's for both single and dual-stage have airborne guidance packages, retro-rockets for separation to avoid bumping the payload, and interface and transition stage. On the two-stage *ASSET* vehicle, the second stage is the first (liquid) stage of the *Delta* vehicle.

In actual practice, the Douglas conversion team has found it can configure the vehicles for different missions concurrently with achieving the standard configuration.

J. P. Rogan, Tulsa division general manager, admitted, however, that "we had to back up on four birds before we and SSD learned we could do this. Now, for example, SSD can order a standard vehicle less the forward section. In other words, mission-oriented changes might be the standard configuration plus or minus some things."

• **Conversion guides**—During the conversion process, the Tulsa team inspects, overhauls and modifies. But since reliability rather than serviceability is the main aim, the conversion work involves more than the "inspect and repair as necessary" process applied in aircraft overhaul and modification, in which the division has considerable experience.

Cost saving is emphasized throughout the entire process, but never at the expense of reliability. All components must be returned to the original design specifications, meaning return to zero-time in the case of time-significant components. The refurbishment portion of the work takes a minimal approach, yet insures new-product reliability.

Many of the modifications are basically updating changes—replacement of components such as switches, relays and other standard items that might have been designed 5-10 years ago—with newer, more reliable parts. Since many of these involve a change in engineering design requirements, they are classed as modifications.

• **Why Tulsa?**—Rogan says Douglas decided to have the conversion work performed by its Tulsa division, even though it had virtually no *Thor* experience, because it had personnel and a system experienced in "rebuilding old equipment."

"The trick of knowing how to take something apart, knowing what portions to replace, doing it at the lowest possible price without downgrading reliability, is rather unique," he says. "I've seen manufacturers of new equipment who couldn't do this. They are used to working only with new stuff, and not within a limited work scope."

In determining what had to be done to the returned missiles and the cost, the division—after first sending some key personnel to gain experience on the West Coast *Thor* production line—disassembled a number of vehicles considered to be "the most pad-weary."

Examination showed the missiles to be in surprisingly good condition. To date, signs of corrosion have been found in only one LOX tank. This was in an area smaller than 10 sq. in., and refurbishers were able to locally clean this spot, mechanically and chemically, to restore the required LOX clean condition.

In only one missile has structural repair been necessary. This was in the propulsion section where both skin and substructure had been damaged. Repair was made by splicing the skin and replacing all stringers in the damaged substructure. ■

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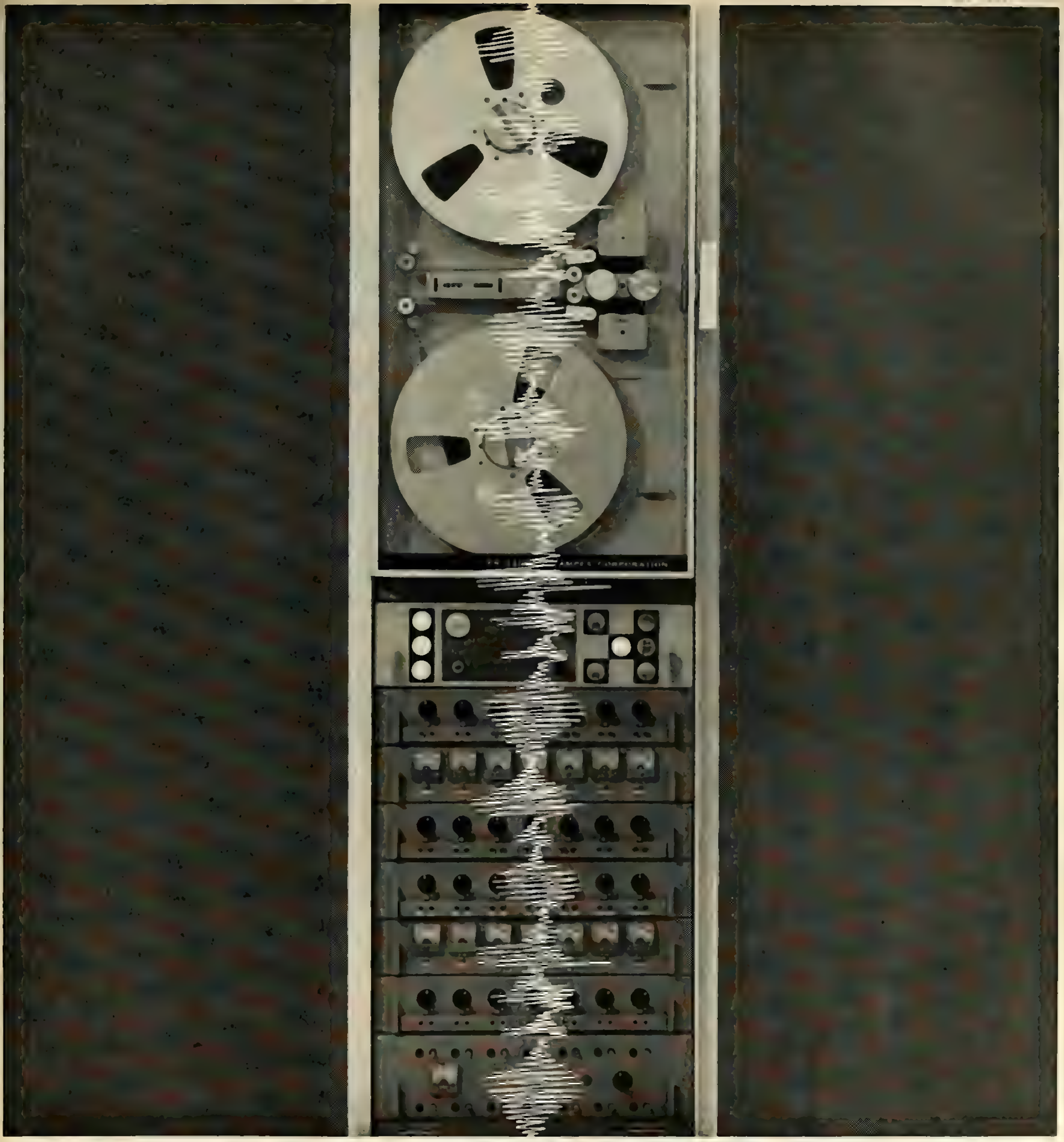

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Beryllium Picked for Structural Job

Lightweight metal approaches status of standard load-bearing aerospace material in Minuteman application at Brush Beryllium

by John F. Judge

CLEVELAND—The introduction of beryllium as a structural component on the Air Force *Minuteman* ICBM is the first major penetration of the high-temperature, lightweight metal into the broad market area of load-bearing applications.

Brush Beryllium Co. regards a $2-million contract for the production of *Minuteman* spacer elements as in indication that the metal is achieving its ultimate market—a standard aerospace structural material.

Fabricating difficulties have been major obstacles, but development of manufacturing techniques by Brush in forming and joining is winning acceptance among aerospace designers.

The high cost of the metal is still a determining factor. Recent developments in non-structural applications—such as a high-enegry solid propellant additive—may help reduce all beryllium product prices.

Even the problem of raw materials supply has been solved with the discovery of large domestic deposits around Topaz Mountain, Utah. Previously, the ores had been imported from South America and Africa. A domestic supply is a necessity for any increasing usage in defense programs.

Beryllium has long been an attractive metal for aerospace applications because of its resistance to high temperatures, its light weight (only hydrogen, helium and lithium precede it in the periodic table), rigidity and strength.

But previous experience in working with other light metals is not usually applicable to beryllium. It is brittle, abrasive and it can be a health hazard if certain standard precautions are not taken.

• Work other than spacers—In addition to the new spacer work, Brush has a host of other contracts, primarily in the non-structural area. These include components and parts for solar cell boards, brakes, mirrors, radiator condensors, *Saturn* actuators and bulkheads, *Gemini* heat shingles, compressor blades, discs and shafts and the *Apollo* guidance frame.

In-house development covers built-up gimbals, pressure vessels, control rods for aircraft and a beryllium-René 41 sandwich. The firm anticipates funding for beryllium elements in the *MMRBM* guidance and control system, *Titan III* truss and guidance tubes, *Sprite, Mariner D, Minuteman* Mark 12 nose cones F-111 control rods and the vertical stabilizer section of the F4H.

PRODUCTION VS. PRICE

The following data, compiled by Brush, reflect the projected prices of basic beryllium products vs. expected production rates in the foreseeable future. If Be powder became a standard additive for operational solid rocket weapon systems, production would increase by orders of magnitude.

BERYLLIUM BLOCK		BERYLLIUM POWDER	
1000 lbs./year	$/lb.	1000 lbs./year	$/lb.
750	$60	300	$50
1,000	55	400	40
1,250	45	500	30
1,500	35	600	25
2,000	30	1,000	20

The potential of the metal has led Lockheed Missiles and Space Co. to create a complete beryllium fabricating shop. The Lockheed facility was established to furnish structural skin panels for satellite vehicles and has succeeded in reaching a production-line operation in both sheet and block beryllium.

The toxicity problem has been successfully met through application of standard industrial hygienic procedures. Beryllium handling and fabricating areas are dust controlled at Lockheed and in all Brush facilities.

• Spacer specs—The spacer is an inter-stage connector on the *Minuteman*. It joins the guidance and control section with the re-entry vehicle .While the spacer contains equipment associted with re-entry, the unit itself does not penetrate the atmosphere.

The spacer consists of a shell, four longerons, four ball-lock access doors, an electrical interface access door and miscellaneous non-beryllium parts.

The shell is a ring-rolled cylinder with a maximum wall thickness of 0.160-in. and a minimum of 0.080 in. The shell develops a guaranteed circumferential tensile strength of 65,000 psi and an axial tensile of 50,000 psi. Its minimum tensile yield strength in the circumferential direction is 38,000 psi and is 37,000 in the axial.

The four longerons are hot-formed by Brush from 0.055-in. cross-rolled beryllium sheet. The formed longeron parts are brazed at their forward ends to a bulkhead machined from hot-pressed block. The brazed joints develop a shear strength of 12,000 psi at room temperature.

The longeron assemblies are joined to the skin by adhesive bonding and riveting. The bonding agent is Shell's Epon 951, and commercial rivets are used. The assembled spacer measures about 32 in. across and 11 in. deep.

The work is being performed under contract to the Lycoming Division of Avco Corp., with actual fabrication being handled on a production basis at Brush's Haywood, Calif., plant.

• Fabrication techniques—Manufacturing developments in six key areas led to the first structural use of the metal. These areas are complex sheet forming, ring rolling, chemical milling, zinc brazing, drilling and bonding.

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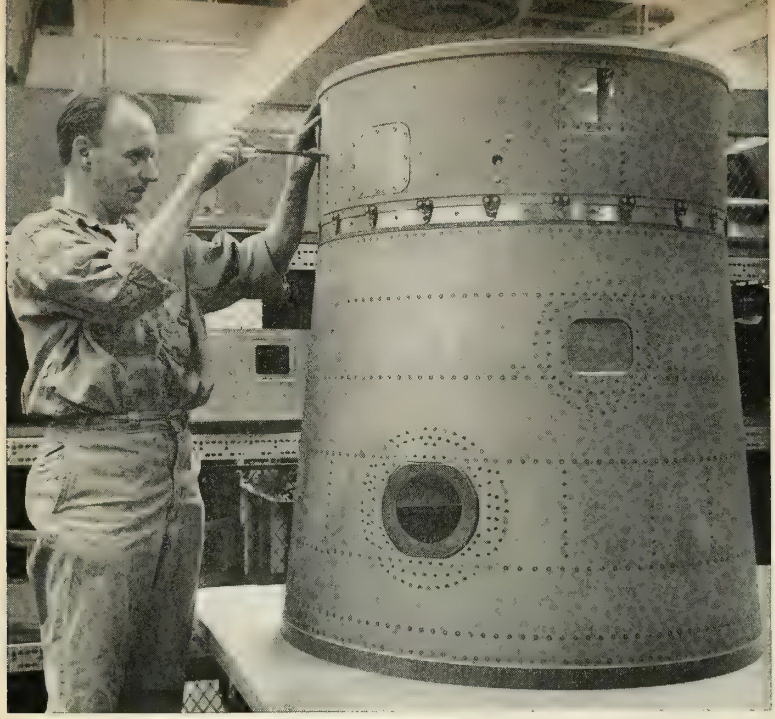
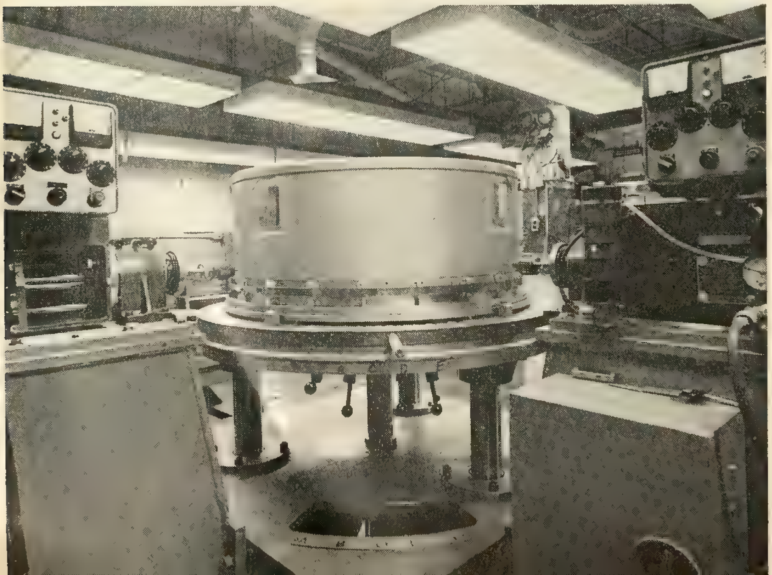


ABOVE: Beryllium spacer attached to experimental Minuteman G&C housing developed by Brush in conjunction with North American's Columbus Div. for NAA Autonetics. LEFT: Brush Product Engineering Manager Bryce King inserts stainlees steel thermal expansion ring into early spacer design. BELOW: Electronically controlled drilling operation puts precise holes in spacer. Holes are drilled undersize and chemically milled to final dimensions. Besides cutting 50% from weight of former aluminum spacer, beryllium structure needs no ascent heat protection. Operational temperatures reach about 500°F.



Sheet forming was in a relatively crude state as little as two years ago. Simple bends and some complex curves could be fabricated. Brush worked up a process consisting of hot forming the sheet in closed dies at 1000°F in air. The key control step is to eliminate hot tension in the dies by always keeping the workpiece in compression. Fairly sophisticated parts can be manufactured with this method.

A cooperative program with the Ladish Co., a forging firm in Cudahy, Wis. in ring-rolling beryllium pieces weighing less than a pound began more than two years ago. The technique has been refined to the point of turning out a basic spacer shell weighing 8.27 lbs. from material weighing about 55 lbs. This is contrasted with the 2,500 lbs. of starting material that would be necessary if machining from block was the only approach.

The scale-up from small rings to the *Minuteman* spacer size posed the major problem. The basic material is a vacuum hot-pressed billet that is trepanned to a heavy-walled ring. The ring is shipped to Ladish while Brush converts the remaining cylinder into a number of smaller beryllium products.

Brush has adapted chemical milling to suit the peculiar needs of a beryllium fabricator. New masking techniques and etchants were developed, together with a process for recovering the metal from the used solutions. Extremely close tolerances have been achieved.

A zinc brazing process is used to establish the structural joint between the forward bulkhead and the longerons. Brush developed a zinc braze which is used at 800° to 850° F rather than the 1700° needed for silver-based brazes.

The low temperature permits creation of a sound joint in air without adversely influencing the mechanical properties of the beryllium. Proper fixturing is the key. Brush progressed through several longeron designs and is now concentrating on a two-piece approach.

Drilling beryllium has always been a difficult task because of the metal's brittle nature. The major problem is break-out occurring during drill penetration.

Brush now uses a Tornetic drilling unit that electronically regulates the torque and feed rates during drilling, minimizing operator error. The spacer has 276 holes and each one has to be near-perfect. In practice, the holes are drilled slightly undersized and the chemical etching process brings them to final dimensions. Brush developed the drilling method in conjunction with the drill manufacturer, and came up with a new drill bit designed specifically for beryllium. ■

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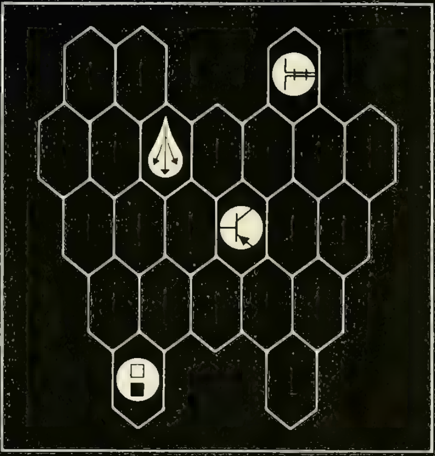

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HONEYWELL

INSTRUMENTATION NEWS

MILITARY EDITION

Number 1-MI

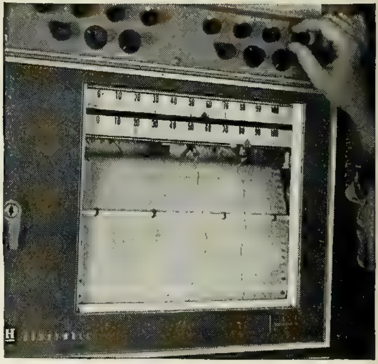
ElectroniK 16 Recorder Introduced

PHILADELPHIA — Honeywell's Philadelphia Division has introduced the *ElectroniK 16* potentiometer, a strip-chart recorder offering many standard features now optional on other recorders.

"The *ElectroniK 16's* modular design concept, along with a number of customer-oriented features that make it convenient to install, maintain and use, makes it the easiest to work with recorder on the market today," said W. A. Forsyth, military market manager for Honeywell's Industrial Products Group.

"For example, the instrument mounts directly into a 19-inch relay rack without using adapters. It has a new, high-performance, transistor servo-measuring unit. Chart-changing time has been reduced to less than a minute. And we can supply an optional pre-loaded chart transport that permits charts to be changed in approximately 10 seconds."

Mechanical layout of the recorder is such, Forsyth said, that most available options and accessories have their own unique location on the chassis. This permits the customer to later add features previously available only as factory-installed or not possible at all if certain other options also were desired.



Operator makes setting on Adjustable Range Unit, optional equipment with two-pen *ElectroniK 16* strip-chart recorder.

"All adjustments can be made simply by sliding the chassis forward," Forsyth noted. "The ink supply can be refilled so easily that the instrument's recording operation is not interrupted. The electrical span and zero controls are made entirely by precision potentiometers specifically designed by Honeywell for this function. And a new type of cam-operated backset switch has been created, again with simplicity of adjustment and stability of operation in mind."

The *ElectroniK 16* is currently available in single-pen, two-pen and multipoint models. Among the options available are an Adjustable Range Unit, chart supply indicator, retransmitting slidewires and event markers. The multipoint recorder has an option whereby any combination of 1 to 24 inputs can be selected by positioning appropriate buttons, and another option giving plugboard selection of alarm points.

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Analog, Digital Data System Cuts Time, Cost for Raytheon

SUDBURY, Mass.—Data that once would have taken six technicians at Raytheon's Space and Information Systems Division here two weeks to record and plot is now being reduced in two hours by one man.

Behind this 168 to 1 time compression is an automatic Honeywell analog and digital data processing system. Designed and built as an Air Force modernization facility from standard components by Honeywell's Special Systems Division, it can record, for selective playback and readout, up to 230 channels of data from 11 remote test areas.

Raytheon lab manager Elmo Pacini checks Honeywell Model 1108 *Visicorder* oscillograph as it monitors wave shape of 24-channel vibration test data.

The analog portion of the system receives data from one shock test area and five vibration test rooms. The digital system handles temperature, barometric pressure and air flow data from five climatic environmental test chambers.

Primary inputs for the analog recording sub-system are 24 accelerometer signals, recorded simultaneously on two-inch FM tape. Wave shapes can be monitored with a Honeywell Model 1108 *Visicorder* oscillograph. Also recorded are shake table frequency, vibration servo control output and voice for a total of 27 analog channels.

The playback sub-system, using the same Honeywell tape transport as the recording network, plots rectified acceleration level vs. frequency on an X-Y plotter in log-log or log-linear form.

The digital system scans at 100 points per minute, measures, linearizes, digitizes and records up to 200 inputs from thermocouples, turbine flow meters and pressure transducers.

Information is fed into a Honeywell ADRT 3200 data logger having an incremental tape recorder. This recorder stores up to 72 hours of 200-channel data on one 2400-foot roll of half-inch tape.

Circle No. 15 on Subscriber Service Card

Industry Facilities

Radiation Incorporated has begun operation of a new Physical Electronics Facility in Palm Bay, Fla. The 40,000-sq.-ft., million-dollar building will house RI capabilities in semiconductor packaging and encapsulating techniques, including glass, metal, ceramics and plastics. . . . *CCI Inc.'s Murdock Machine and Engineering Co., Irving, Tex., has put into operation a honeycomb-bonding facility. The 115,000-sq.-ft. plant is located on a 10-acre site near Ft. Worth's Greater Southwest International Airport. Murdock specializes in the machining and processing of intricate profiles in limited-run missiles and aircraft.* . . . Philco Corp.'s new microelectronics manufacturing facility at Lansdale, Pa., is scheduled to be fully operational and in volume production by June. The 100,000-sq.-ft. building, along with its equipment, represents a $4.5-million investment in the production of TTL microcircuits and in Micrologic and Milliwatt Micrologic circuits covered by the firm's cross-licensing agreement with Fairchild Camera and Instrument Corp. Plans call for the production of 50,000 circuits a month by the end of 1964 and an eventual capacity of 100,000 circuits a month by mid- or late-1965. . . . *Cornell Aeronautical Laboratory, Inc., has placed in operation a new hypersonic test facility in Buffalo, N.Y. The High-Energy Shock Tunnel has a 96-in. test section, employs a 30,000-psi heated-hydrogen driver, and has the following capabilities: stagnation temperature, 8,000° K; test section velocity, to 18,000 fps; Mach number range, 5-30.* . . . Thermal Dynamics Corp., Lebanon, N.H., has made available an entry simulation facility for hyperthermal testing studies on a contractural basis. Thermal's plasma equipment is said capable of simulating various ranges of altitude, gaseous mixtures, temperature and velocity required to duplicate actual re-entry conditions. Capabilities include: temperatures, to 18,000° F; velocities, to 17,500 mph; altitudes, to 300,000 ft. . . . *The Ventura Div. of Northrop Corp. has opened a 10,000-sq.-ft. facility in Albuquerque, N.M., to provide expanded scientific support of nuclear energy programs and missile testing. Special emphasis will be placed on design of radiation-resistant electronics components and circuits.*

New Activities

United States Steel Corp. and National Distillers and Chemical Corp. have formed an equally owned company, Reactive Metals, Inc., to produce titanium sponge and metal and to fabricate finished mill products. Production facilities of RM will consist of ND's existing special metal facilities in Ashtabula and Niles, Ohio. . . . *David M. Ellner & Assoc., a firm specializing in executive search and recruitment, has been established in New York. The firm will be active in the fields of aerospace, data processing, chemistry, pharmacy and finance. Ellner will have field offices in Los Angeles and Zurich.* . . . Scientific Data Systems, Santa Monica, Calif., has formed a Hybrid Computation Group to work on hybrid computer systems and analog and digital simulation techniques. The group will also work with the SDS DES-1 Differential Equation Solver, a general purpose digital computer that is programmed using analog techniques. . . . *Cleveland Instrument Co., a subsidiary of The Bendix Corp. has become the Cleveland Instrument Plant of Bendix's Micrometrical Div., Ann Arbor, Mich. The acquisition gives the Micrometrical Div. a complete line of instruments for measuring surface texture, geometry and extremely small linear dimensions.*

Mergers and Acquisitions

Hewlett-Packard Co., Palo Alto, Calif., has announced completion of negotiations with Mechrolab, Inc., a manufacturer of medical and scientific instruments, to purchase the assets of that firm. Mechrolab is located in Mountain View, Calif. . . . *Ling-Temco-Vought, Inc., Dallas, has consolidated parts of its Astronautics Div. with its LTV Vought Aeronautics Div. Move was said to be an effort "to improve overall corporate efficiency and reduce operating costs."*

PERT Goes Civvy

Booz, Allen & Hamilton, a member of the Government-Industry team that created PERT (Program Evaluation and Review Technique) for use in the *Polaris* program, reports that the technique is coming into its own in commercial work. BA&H reports there is a marked increase in non-defense applications of the technique. In 1959, the company reports, 81% of firms using PERT applied it exclusively or partly to Government work, but by the end of 1963 half the companies surveyed were using PERT only for commercial work. Another 35% were using it for both commercial and Government work.

Firms Cited for Assist to Small Business

Small Business Administration head Eugene Foley has congratulated 28 major Government contractors for expanding contracts with small business to more than $9.4 million under a co-operative, industry-wide subcontracting program initiated by SBA last May. Under current procurement regulations, contractors must set up small business subcontracting programs on all Government prime contracts worth more than $1 million—as well as on subcontracts valued in excess of $500,000. Foley described the procurements rules' requirements in this area as "bare minimums," and said SBA has been working to encourage industry to do more than the rules require. As a result of SBA efforts, Foley reports, "28 of the Government's biggest contractors agreed with SBA's plan and have fully cooperated. . . . They actively seek small business sources of supply from SBA and from military contracting officers without regard to dollar limits of their prime contracts."

Motorola Proposes Combining Apollo Communications into Single System

Use of one S-band for rendezvous, tracking and voice communications offers reduced weight and cost, increased reliability and range

by Rex Pay

SCOTTSDALE, ARIZ.—Unification of rendezvous, tracking and voice communication into a single S-band system would cut weight and costs, and boost reliability in spacecraft of the *Apollo* type, claim officials at the Military Electronics division of Motorola, Inc.

Rendezvous could be accomplished over distances greater than one thousand miles. In its proposed form, the CW S-band system would bring the two spacecraft within 50 ft. of each other, and docking would be carried out visually.

Using the single S-band carrier, rendezvous, tracking, data transfer and voice communications could be accomplished simultaneously between spacecraft. The same equipment would provide communication between spacecraft and Earth at lunar distances.

To give the capability of rendezvous to each spacecraft and to improve reliability, the S-band transponders on board the vehicles would be modified and duplicated in the command and service modules (CSM) and the Lunar Excursion Module. Range and range-rate equipment that is basically a scaled-down version of the Goddard Space Flight Center R&RR equipment would be added, together with angle transducers on the S-band antennas.

- **Redundancy breeds success**—The increased redundancy indicates a 0.999967 probability of succes for a 14-day mission (four days on the moon). This does not take account of necessary repairs made by exchanging modules between duplicated sets of equipment.

For successful rendezvous, only one ranging equipment and two transponders (one in each spacecraft) need be operative.

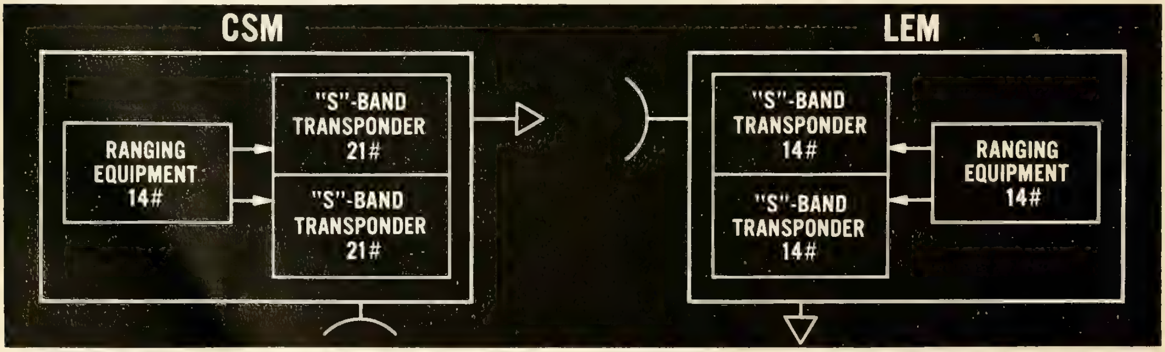
Original concepts for LEM and CSM electronics seem to have resulted from separate teams of communication, tracking and rendezvous designers, each producing a separate optimized system. Each of these systems required its own antenna, and each required duplication for reliability.

Already the move toward a unified system has been made by putting deep-space and near-Earth tracking and communications into a single S-band system instead of S-band, C-band and VHF.

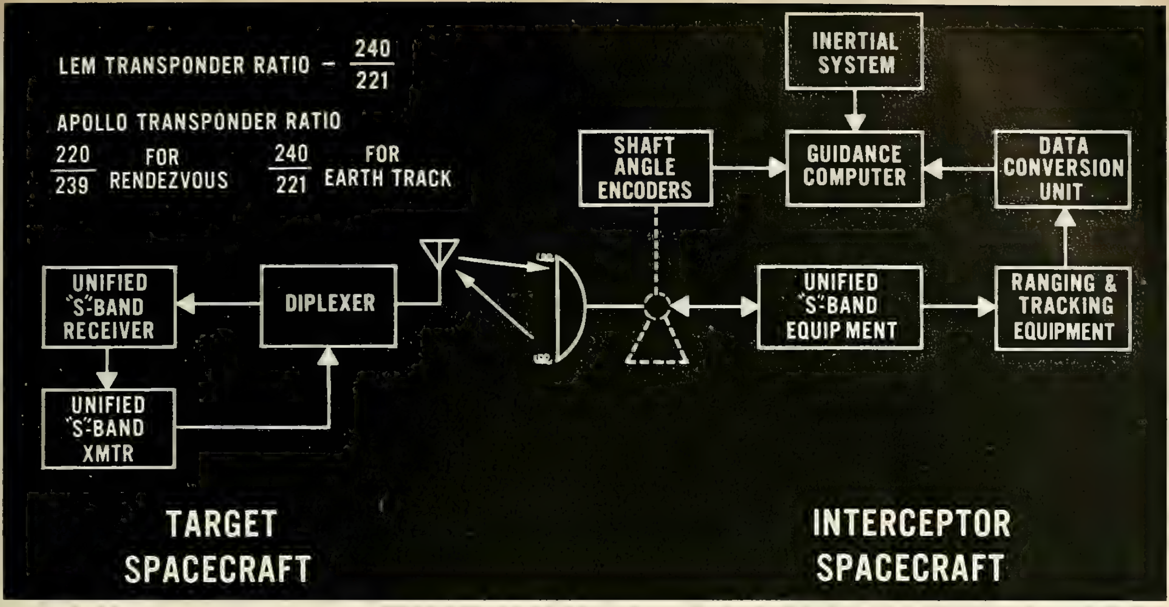
Motorola suggests that extension of this principle to give the S-band equipment the rendezvous capability would be both logical and desirable. Use of such unified equipment would be particularly valuable for a logistics vehicle that makes repeated rendezvous with a space station.

The proposed system would make increased use of equipment that is already on board. It would provide a range accuracy of ±10 meters, and a range-rate accuracy of 0.1 meter per second. Expected accuracy of sensor angular measurement is 0.06 degree.

- **CSM hardware**—Basic equipment



Rendezvous and communications with two-way tracking could be provided by S-band system with redundant transponder.



Overall rendezvous and tracking link requires shaft-angle encoders and modified monopulse equipment to extract angle information.

on the CSM would be a modified S-band transponder with 750 milliwatts of transmitted power output, an end-fire array with a gain equivalent to a four-foot parabolic antenna and an omni-directional antenna. The LEM equipment would be similar except that a steerable antenna with a gain equivalent to a two-foot antenna would be used.

The pilot of the interceptor spacecraft searches for the target vehicle by manually controlling the antenna. On acquiring the target, the pilot switches to automatic track. At the same time, a carrier frequency is transmitted that is phase-modulated by range tones. This signal is received through the omnidirectional antenna of the target aircraft, processed by the on-board equipment and re-transmitted at a different carrier frequency.

In turn, this signal is received by the interceptor and demodulated. Range is measured by comparing the phase of received tones with that of the transmitted tones. Range rate is measured from the Doppler frequency on the carrier. Angle information is read out from shaft-angle encoders on the antenna.

A computer utilizes the relative positions of the two vehicles to generate the required velocity commands for rendezvous.

The phase delay of the ranging side tones is directly proportional to the two-way range between the interceptor and target spacecraft, plus equipment delays. The range-tone output consists of a 163.84-kc subcarrier modulated by low-frequency ranging tones in a pseudo-random sequence. The 163.84-kc frequency is used to measure the finest increment of range. Lower frequency tones are used to resolve ambiguities.

A data conversion unit converts the phase difference between the transmitted and received tones into the digital format required by the spacecraft computer.

For Doppler frequency measurement, frequency coherence is maintained from the interceptor transmitter to its receiver. The output of the Doppler extraction unit consists of the two-way Doppler frequency plus a bias frequency. Again, these data are converted to a digital format.

Pointing of the antenna is achieved with a highly-modified phase-monopulse system.

- **Key to workability**—The feasibility of the system depends on the capability of the CSM transponder to operate at two coherent transponder ratios and at two separate frequencies. The implementation is claimed to be simple, calling for only a small addition to the transponder.

The transponder receives, amplifies and emodulates the tones on a carrier whose frequency is 240/221 times the received frequency, if the LEM is the target, or 220/239 times the received frequency if the CSM is the target. The first frequency ratio is that used for unified S-Band operation. The second is specific to rendezvous.

For unified S-band operation of the transponder, the incoming S-band signal is received at 110.5 times the receiver VCO frequency. In fact the receiver VCO frequency is phase-locked to the incoming signal at 1/110.5 times the received frequency. The transmitted frequency of the transponder is obtained by multiplying the VCO frequency by 120. This gives the required unified S-band ratio.

To get the rendezvous ratio, the transponder must receive at 119.5 times the VCO frequency and transmit at 110 times the VCO frequency. This is achieved by changing the final multiplier in the mixer/local oscillator chain to X13 instead of X12.

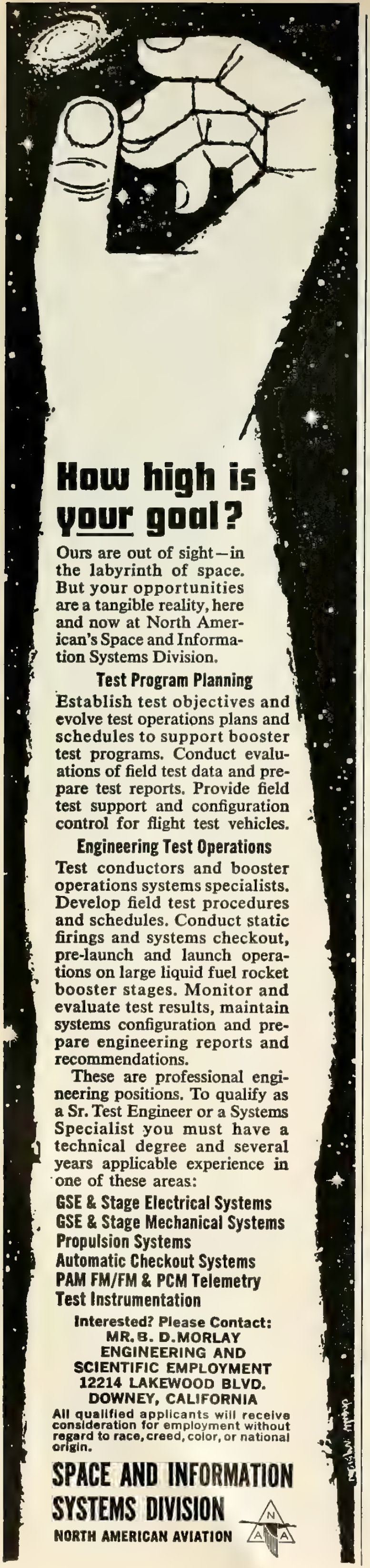
The receiver will then phase lock to an incoming signal that is 119.5 times the VCO frequency.

The choice of a ratio of 220:239 instead of the true inverse (221:240) eliminates problems of coherence and simplifies the Doppler extraction process, says Motorola. Use of a dual-frequency VCO and a dual filter before the loop-phase detector provides the dual-frequency capability. Transponder frequency ratio is controlled by turning on the appropriate multiplier power amplifiers.

- **One CSM tracks another**—A modification of the lunar rendezvous equipment would allow one CSM to track another at a range of 250,000 miles at an accuracy slightly below that of rendezvous.

To carry out this tracking, both spacecraft would use 20-watt traveling-wave-tube amplifiers. Pseudo-random noise would replace the range tones, and PN code correlation would be used on board the target spacecraft.

This capability could be used for translunar on-board trajectory determination and tracking before re-entry. The system could also be of value for Earth-orbital rendezvous, particularly with manned orbiting space stations, which may require long rendezvous paths. ■



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Sandia Development Tops IEEE Hardware

by Charles D. LaFond

New York—New ferroelectric multi-remanence memory elements, developed by Sandia Corp. for use with nuclear weapon systems, may offer a means for greatly increasing computer memory capacities and at the same time simplify the logic circuitry.

Although still in early development, the new elements may prove ideal for use in spacecraft guidance and navigation computers, developers claim. Early experiments have indicated that the ceramic employed is relatively insensitive to high-energy particle irradiation, high electromagnetic fields and severe temperature variations.

Described in their paper, "Polycrystalline Ferroelectric Multi-Remanence Memory Elements," at the recent International Convention of the Institute of Electrical and Electronic Engineers here (Mar. 23-26), the ceramic element is capable of storing data in at least ten stable states.

Conventional bi-remanence memory devices, the authors pointed out, that are now in broad computer use are capable of storing information in only two stable states (and thus are capable of only storing two digits).

In effect, then, said authors C. E. Land, G. W. Smith and I. D. McKinney, the multi-remanence memory element would permit the use of a decimal number or system for arithmetic processes rather than the often cumbersome or inconvenient binary system.

Configurations already produced in breadboard form reportedly have been capable of providing continuous, nondestructive readout.

- **IEEE convention summary**—The current slowdown in the defense systems market apparently has had a direct effect on the electronics industry. Attendance decreased for the second straight year.

Speculations concerning the drop were varied and probably represented the accumulation of causes contributing to the decline. Some pointed the finger at a general tightening of controls on expense accounts, others at reduced travel budgets resulting from generally lower profits in the industry.

Others felt that the drop from an expected 75,000 to 66,650 may simply have been the result of an attempt by management to send only those engineers that might benefit most through their attendance.

The attendance squeeze certainly was not reflected in the number or size of exhibits. A sellout, as usual, the Coliseum and the New York Hilton Hotel bulged with the products of 1,179 exhibitors strung out over 2½ miles.

Footsore and weary engineers trudged back and forth over four floors through corridors created by more than $20 million worth of equipment at the two exhibit areas.

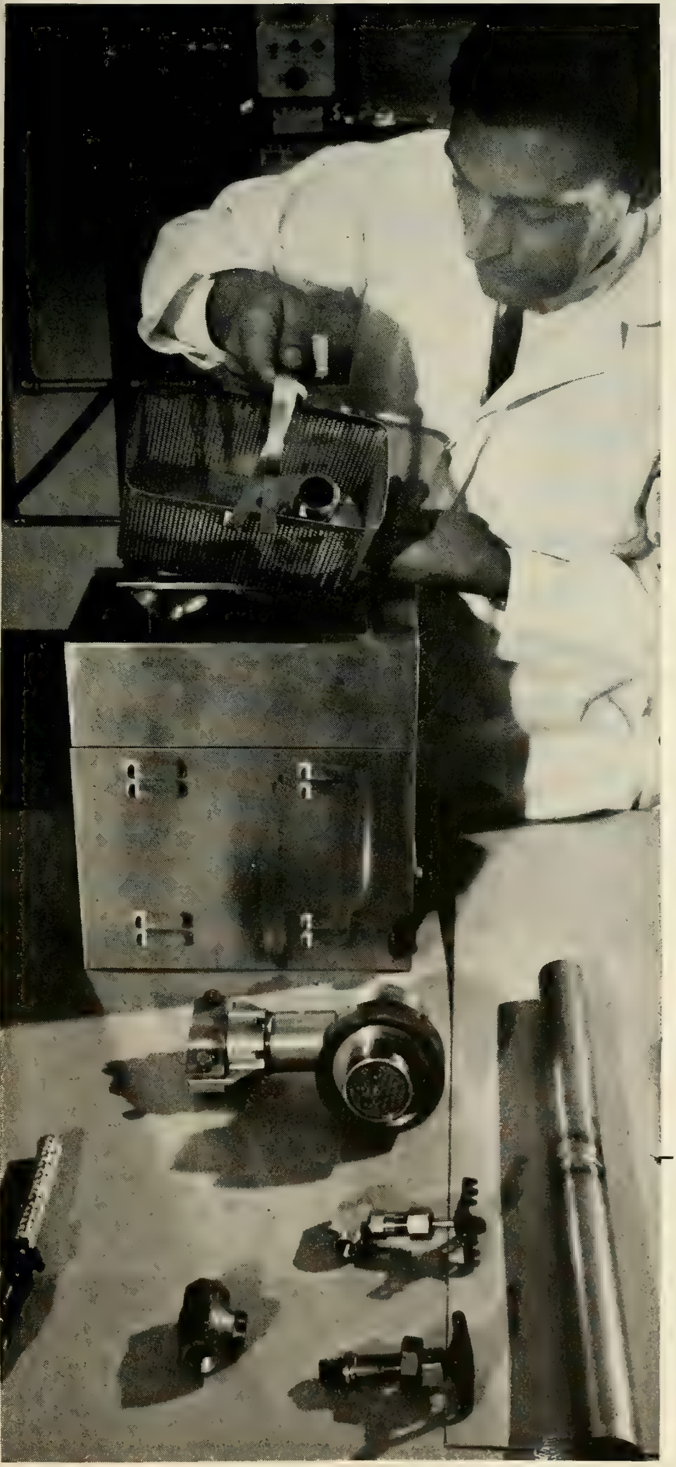
"Gee-Whiz" advances in the state of the art were noticeably lacking this year. Instead, new or expanded product lines in the field of microcircuitry were overwhelming in their variety.

In the 64 technical sessions, generally sparse audiences were subjected to 312 papers, too often delivered in halting monotones. A symposium, however, discussing the impact of microelectronic integrated circuits drew a standing-room-only audience (M/R, Mar. 30, p. 13).

- **Material advance**—Key to the Sandia advance in memory elements was the development of a new technique for hot-pressing piezoelectric ceramics. (Credit for the technique is given by Sandia to G. H. Haertling of the Materials Research Division.) The material, rhombohedral, lead-zirconate-titanate ceramic, so far has been formed into two-terminal bar or disc resonators.

Data storage is achieved, the authors said, by applying a fixed number of voltage pulses of sufficient magnitude

How General Dynamics/Electric Boat precision-cleans missile launching-tube components for Polaris subs!



PROBLEM: Pneumatic launching-tube systems for the Polaris, involving miles of pipes, tees, valves, unions, etc., must be kept scrupulously clean at all times, according to Electric Boat. In an environment of high air pressure, the most minute organic contaminants could support a dangerous explosion. The previous cleaner was rated only 83 to 88% effective in removing a known hydrocarbon contaminant; also it had to be heated to 160°F. before use.

SOLUTION: All launching system components are now cleaned in an ultrasonic bath of FREON fluorocarbon solvent, both initially and during subsequent maintenance. FREON scores 100% every time on the hydrocarbon contaminant test, and works perfectly at ambient temperature.

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and duration to switch a small percentage of the ferroelectric domains. The approach effectively causes a polarization change in the material in small increments; the resulting condition is stable and detectable by the small-signal response of the element.

The latter is sensitive to the state of polarization, and the response is indicative of the information state. The element itself is interrogated with a small signal. The polarization state is unaffected and readout is non-destructive.

Stability of access points, the authors stressed, is extremely important and data stored at a fixed point or level can be found indefinitely at precisely that point.

The authors stressed that while they have only concerned themselves with ten storage levels or states so far, a memory element could easily have "hundreds" of access points.

Further, they foresaw no indication that data storage could not be achieved in each grain of material. ■

SPACE ELECTRONICS

MIT Panel Dissects West Ford at IEEE

by Michael Getler

NEW YORK—First large scale technical presentation covering all major aspects of Project West Ford, the long-range passive space communications system in which an artificial belt of orbiting microwave dipoles has been created some 2,000 nautical miles above the Earth, was presented at the International IEEE meeting here.

Sixteen scientists from MIT's Lincoln Laboratory, headed by West Ford Project Chief and Associate Head of the Communications Div., Walter E. Morrow, Jr., took part in the six-paper session last week.

With active military space communications systems still being studied and debated within DOD, Project West Ford is gaining considerable favor with some DOD planners as an attractive route for secure long-range military communications (M/R, Mar. 30, p. 84).

Whereas the orbital features of the program have always been of interest, the briefing here laid considerable stress upon the advancements in the ground space communications environment that have come about due to the push on the West Ford experiment.

For example, the project has advanced the state of the art considerably in development of high-average-power X-band transmitter tubes, starting with use of a Varian 5-kw klystron, and progressing through a 40-kw GE multiple-beam klystron into Varian devices exceeding 100-kw capacity. The latter will be used with the new Haystack antenna at the Laboratory's complex in Massachusetts for further West Ford experiments (M/R, March 23, p. 26). Development of 300-kw tubes is also being pressed.

Low-noise front ends have also been built into both 60-ft. dishes, one in Camp Parks, Calif. and the other in Westford, Mass., which now make up the West Ford system.

The dish at the Massachusetts site uses a Hughes open-cycle, helium-cooled maser amplifier, which has reportedly brought overall system temperature down to a "highly respectable" 60°K.

The need for low-noise systems is made clear when scientists point out that despite high transmitted powers, the 0.15-degree antenna beams are looking at a common volume in the belt at a 2,000-n.-mi. range, which contains only about ten thousand 0.0007-in.-dia. dipoles, an amount that sounds deceptively large, but in fact represents a reflecting mass of less than 1 gram of copper.

- **Other advances**—Also, major gains are cited in development of signal processing equipments for handling signals carried on "a dispersive channel," one that introduces two kinds of distortion into a signal, one being due to multipath time-delay problems and the other due to Doppler frequency smearing.

Scientists also point to state-of-the-art gains resulting from efforts to approach theoretical surface tolerances for

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*The Space Guidance Center was built on a 700-acre site in 1957 to contain IBM's burgeoning defense and space efforts. Current projects include: TITAN II and III, SATURN I and V, GEMINI and MOL.

dishes of this size and precision pointing capabilities at short wave-lengths.

The 60-ft. paraboloid antennas at both sites use Cassegrain feeds. While simultaneous two-way transmission can be carried on between the sites via the belt, the California station is used primarily as a transmitter with a 40-kw CW capability at 8,350 mc. The East Coast site operates at 7,750 mc.

Stable solid-state oscillators and multipliers form the exciter carrier and receiver local oscillator signals. Frequency translation from an IF of 60 mc up to X-band in the exciter and back down to 60 mc in the receiver is achieved using crystal mixers and waveguide filters.

- **Global communications capabilities**—In a broad discussion of the West Ford system concept, Morrow told the IEEE audience that continuous global communications—with single-hop circuit lengths of 10,000 km possible—could be achieved with two orbital belts (equatorial and polar) at altitudes of about 5,000 km.

Based on what has been learned from the West Ford experiment, he reported that scattering cross sections of 3,000 square meters per kilogram at 8,000 mc can be achieved with dipoles having diameters in the order of 3×10^{-3} cm. The dipole bandwidth is of the order of 7% or about 500 mc.

A continuous ring of orbiting dipoles can be formed from a single satellite dipole dispenser within one or two months if the dipoles are dispensed with a distribution of velocities up to a few meters per second. An initial ring thickness of 10 to 30 kilometers is achieved. Differential solar radiation perturbations are expected to produce a gradual increase in the ring thickness. However, it is expected that a useful lifetime of several years can be achieved through proper selection of orbit and dipole design.

The detailed radio propagation characteristics will depend upon the beamwidth of the ground antennas and the spread in orbital velocity of the dipoles. With antennas of about 20 meters aperture, multipath time delay distortion of 100 to 300 microsec. can be expected, Morrow reports. The spread in velocities of the dipoles as they pass through the common volume of the antennas can be expected to produce variations in the detailed multipath structure at rates of 200 to 1,000 per second.

Modulation-demodulation techniques, which do not require detailed knowledge of the received signal phase, are desirable because of the rapid channel variations. Digital modulation techniques have been devised that permit reliable digital transmission over such disturbed channels with a ratio of energy per bit to noise power per cycle of as small as 10 db.

- **Dual-role tests**—The experiments performed to date with West Ford, which was placed into orbit last May 9 with first radar observation of the dipoles on May 12, have been aimed at physical characteristics measurement and communications capabilities.

In physical measurement, both monostatic experiments and bi-static propogation experiments have been run.

In a typical monostatic radar experiment, an antenna beam is pointed at a constant co-latitude on the belt and then slowly scanned across the belt to obtain a "slice;" data is obtained across a 48-mi. range gate in sixteen 3-mi.-range boxes. Other experiments involve beam scanning along the belt in a wide arc for orbit parameter estimation. Often a pair of runs 12 hours apart is made to obtain data on two quadrants of the orbit.

Bi-static experiments usually involve transmission of CW or phase-shifted signals from West to East via the belt. These permit direct measurement of path loss; cross section in the common volume of the two interecting antenna beams may then be inferred.

Several successful estimates of belt orbital parameters have been made, according to the Lab, which agree closely with predictions. X-band radar measurements and vacuum chamber lab tests indicate that 25-60% of the launched dipoles were actually dispensed in orbit. Measured variation of dipole density around the orbit showed the anticipated initial dense region near the dispenser and the increasing uniformity of dipole density around the orbit with time.

- **Deployment error**—The failure to deploy more of the dipoles is attributed to the timing of the initial radio command, which according to the Lab, was sent later than intended. The delay altered the angle at which the Sun's rays illuminated the dipole package from 90 degrees to the package spin axis to 19 degrees thereby altering the major heat input path and subsequently overstressing the packages at the center hub.

The growth or dispersion of the West Ford belt with time is determined initially by the differential dispensing velocities, but the dispersive effects of sunlight pressure and the Earth's equitorial bulge begin to dominate after several months, the scientists report.

The initial orbital parameters were chosen so that sunlight pressure would cause the perigee height of the dipoles to decrease monotonically at an average rate of 3.7 kilometers per day, with the bulge action insuring a favorable orbit orientation. Radar measurements of actual changes to date agree with previously calculated ones to within experimental errors, the Lab reports.

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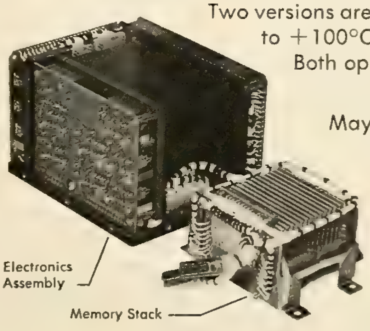

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• 3-year orbit—These results lend credence to the prediction that most of the dipoles will re-enter the atmosphere within three years, according to the Lab, and that no individual dipole will remain in orbit for more than five years.

Two types of bi-static communications experiments have been carried out, both involving West Coast transmission.

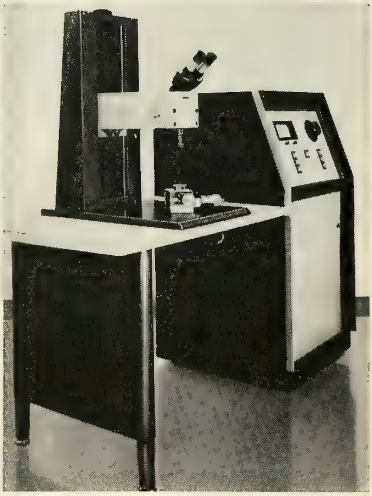
The first involved measurement of the bi-static scattering function of the belt. The transmitted signal consisted of a continuous carrier bi-phase modulated by a maximal length-shift register sequence; shift periods of 5, 10, 15 and 20 microsecs. were used. Correlation detection of the received signal in 20 time-staggered channels provided resolution of multipath into 20 range cells of width equal to the shift period.

Behavior of the scattering function, according to the lab, has been substantially as predicted. The spectral width of the received signals (Doppler spread) has increased from about 500 cps shortly after launch to about 2 kc four months later. For certain path geometries, the mean Doppler frequency varied monotonically with propogation delay. Except during the initial dispensing phase, the multipath spread has been limited, primarily by the beam dimensions, to about 100 microsec.

In the second type of experiment, digital data are transmitted by binary frequency shift keying with frequency hopping to counteract intersymbol interference. Initially, rates around 20,000 bits/sec. were achieved, and PCM voice was transmitted. As the belt spread, the rate decreased, dropping to about 50 bits/sec. four months after launch. ■

New Product of the Week:

Laser Microwelder



A laser welder, designed for microwelding operations on an assembly line, has been introduced by Hughes Aircraft Co.'s Electronic Products Div.

The Model 500 utilizes a pulsed ruby laser to achieve bursts of highly concentrated energy. Beam energy is adjustable from 0.1 to 2.0 joules per pulse. Repetition rate is 12 pulses per minute at 1 joule or 9 pulses per minute at 2 joules. Pulse duration is 0.5 to 1.5 milliseconds.

The unit offers either manual or automatic firing control. Weld spot size is adjustable from 0.005 to 0.020 in. Beam energy is reproducible to within ± 3%. The unit accepts regular 110v ac, with a peak current draw of 20 amps. Average power input from maximum repetition rate is 350 watts. Flashlamp expectancy is 10,000 shots.

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Computer Transistors

Fairchild Semiconductor has introduced two computer transistors—one a silicon PNP device and the other a film driver.

The epitaxial PNP device, the 2N 3304, has a T_s of 30 nanoseconds maximum at a 10/10/10 ma condition. The f_t of the device is typically 500 mc at 10 ma and 5v. Saturation voltage is 0.15v maximum with I_c at 10 ma and I_b at 0.1 ma.

The film memory core driver is also silicon Planar epitaxial and is designated the 2N 3303. The device has a maximum turn-on time of 15 nanoseconds, a maximum turn-off time of 25 nanoseconds with a collector current of 1 amp and a base current of 100 milliamps. Saturation voltage is 0.7v.

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The Model EMC-10 interference analyzer, for use in the 20-cps to 50-kc frequency range, is being marketed by Electro-Metrics Corp.

The solid-state instrument features all-electronic tuning, making possible automatic scan without mechanical drive. This fulfills MIL-STD-826 specifications.

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$3,900,000—**North American Aviation, Inc.,** Space and Information Systems Div., Downey Calif., for manufacture of modification kits related to *Hound Dog* missiles.

$3,745,000—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for continued work on a satellite control network.

$3,500,000—**Boeing Co.,** Seattle, for production of equipment related to *Minuteman* ICBM's.

$2,387,042—**Radio Corp. of America,** Moorestown, N.J., for production of spare parts for radar equipment.

$2,333,282—**Adler Electronics, Inc.,** New Rochelle, N.Y., for communications network.

$2,250,000—**Martin Marietta Corp.,** Denver, for installation of modification kits in *Titan I* nuclear missiles.

$2,189,425—**General Precision, Inc.,** San Marcos, Calif., for components of navigational computer sets.

$2,000,000—**Litton Systems, Inc.,** Woodland Hills, Calif., for inertial navigation system components.

ARMY

$11,969,880—**Model Engineering & Manufacturing Corp.,** Huntington, Ind., for radio equipment.

$6,000,000—**International Business Machines Corp.,** for rental of computer systems at various Army installations.

$3,905,448—**Hercules Powder Co.,** Wilmington, Del., for loading and essembling various missile components, propellants and explosives.

$3,635,484—**Raytheon Co.,** Lexington, Mass., for work on guidance and control system for the *Hawk* missile.

$1,900,000—**General Dynamics Corp.,** Stromberg-Carlson Div., Rochester, N.Y., for production of electronics equipment.

$1,900,000—**Northrop Corp.,** Nortronics Div., Anaheim, Calif., for *Hawk* missile steering mechanisms.

$1,161,864—**Martin Marietta Corp.,** Orlando, Fla., for modification kits for *Pershing* missiles.

$1,000,000—**Burroughs Corp.,** Detroit, for production of classified electronics equipment.

$800,000—**Tamar Electronics, Inc.,** American Gyro Div., Los Angeles, for airborne test equipment to be used with *Lance* missiles.

$712,402—**Sperry Rand Corp.,** Sperry-Utah Div., Salt Lake City, two contracts for work related to *Sergeant* missiles.

$181,835—**Hayes International Corp.,** Birmingham, Ala., for additional work on the *Pershing* missile trainer program.

NAVY

$49,300,000—**Lockheed Missiles and Space Co.,** Sunnyvale, Calif., for production of *Polaris A3* missiles.

$3,463,000—**Sperry Rand Corp.,** Sperry Gyroscope Div., Great Neck, N.Y., for various engineering services.

$2,805,000—**Texas Instruments Inc.,** Dallas, for work on guidance control for the *Shrike* missile.

$120,000—**Tung-Sol Electric, Inc.,** Newark, N.J., for power supply converters.

NASA

$158,000,000—**North American Aviation, Inc.,** Rocketdyne Div., Canoga Park, Calif., for 71 F-1 rocket engines for the *Saturn V*.

$1,300,000—**Telecomputing Services, Inc.,** for further operation of computers and data-transmission equipment at Michoud Operations, New Orleans, La.

$129,273—**Martin Marietta Corp.,** Baltimore, for research on non-linear differential equations and control theory.

$121,204—**Hayes International Corp.,** Birmingham, Ala., for a hydraulic test pumping system.

$100,000—**General Precision, Inc.,** Link Div., Binghampton, N.Y., for maintenance and service of *Gemini* simulators and other training devices at the Manned Spacecraft Center, Houston.

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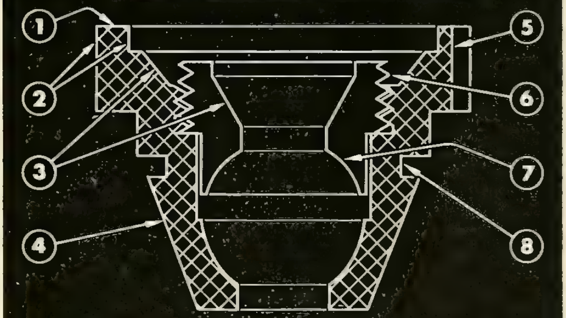

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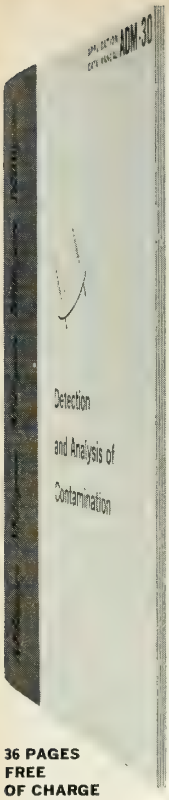

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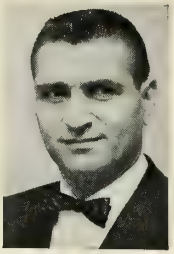
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Richard B. Miller: Named director of personnel and administration for the Space Systems Div. of Fairchild Stratos Corp., Washington, D.C.

William J. Moreland and **Damon Van Utt:** Elected vice presidents of Giannini Controls Corp., Duarte, Calif.

George DiPietro: Appointed vice president of Vacuum Industries, Inc., Somerville, Mass.

Robert L. Vader: Appointed vice president of engineering and research for Lockheed Aircraft Service Co., Ontario, Calif.

R. J. Rutherford: Elected a vice president of Vapor Corp., Chicago.

Donald H. Pile: Named Air Force requirements engineer for sensor products at General Dynamics/Electronics, San Diego.

Jonas M. Shapiro: Elected president of Manson Laboratories, Inc., Stamford, Conn.

Dennis M. Colbert: Appointed vice president and technical director of Brooks Research, Inc., East Rochester, N.Y.

John B. Bradfield: Appointed controller for D. B. Milliken Co., Arcadia, Calif.

Roger E. White: Jointed Ling-Temco-Vought, Inc., Dallas, as marketing manager of its Temco Aerosystems Div.

Norman Pollack: Appointed director of engineering at Victory Electronics, Inc., Syosset, N.Y.

Lyman E. Wood: Appointed regional director of military and space relations for the Electronic Instrumentation Div. of Lear Siegler, Inc., Anaheim, Calif.

J. W. Cohoe: Named advertising manager-industrial products for Ex-Cell-O Corp., Detroit.

Frederick M. Bender: Named vice president of the Instrument Div. of Sunbeam Electronics, Fort Lauderdale, Fla.

Homer T. Meaders: Appointed corporate public relations representative for Eitel-McCullough, Inc., San Carlos, Calif.

Dr. John Madigan: Jointed Zenith Radio Corp., Chicago, as a division chief in the solid state research group.

Henry M. Ross: Elected vice president-marketing of Aero Geo Astro Corp., Alexandria, Va.

James A. Paine: Promoted to area sales manager for the Western United States for Motorola Semiconductor Products, Inc., Hollywood, Calif.

Dwight E. Johnson: Appointed manager, southeastern region, for the Defense Marketing organization of the UNIVAC Div. of Sperry Rand Corp., Cocoa Beach, Fla.

Gregg R. Walden: Promoted to director of commercial marketing of C-E-I-R Inc., Arlington, Va.

William J. Slawson: Appointed general sales manager for The Arnold Engineering Co., Marengo, Ill.

Ray W. Macdonald: Elected executive vice president of the Burroughs Corp., Detroit.

George B. Achtmeyer: Appointed director of manufacturing at Sperry Gyroscope Co., Great Neck, N.Y.

Gilbert E. Mandell: Appointed product manager of the Power Tube Dept. of the Du Mont Electronic Tube Div. of Fairchild Camera and Instrument Corp., Clifton, N.J.

A. J. Vick: Named director of marketing for ITT Kellogg Communications Systems Div. of International Telephone and Telegraph Corp., Chicago, Ill.

Robert M. Jones: Elected vice president of government engineering for Admiral Corp., Chicago, Ill.

John A. Caves: Appointed treasurer of Lear Jet Corp., Wichita, Kan.

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22nd Annual Meeting, National Aerospace Services Assn., International Inn, Washington, D.C., Apr. 6-7.

IEEE Rubber and Plastics Industry Conference, Sheraton-Mayflower Hotel, Akron, Ohio, Apr. 6-7.

Solar Energy Symposium, University of Florida, Gainesville, Apr. 6-7.

Pricing and Negotiating Prime and Subcontracts in the Defense and Aerospace Industries Seminar, sponsored by the Contract Management Institute, Palmer House, Chicago, Apr. 6-10.

IEEE International Conference on Nonlinear Magnetics, Shoreham Hotel, Washington, D.C., Apr. 6-8.

ASME Design Engineering Conference and Show, McCormick Place, Chicago, Apr. 6-9.

ISA Measurement and Control Instrumentation Div. Symposium, Floridian Hotel, Tampa, Apr. 8-10.

48th Annual Meeting, Federation of American Societies for Experimental Biology, Conrad Hilton Hotel, Chicago, Apr. 12-18.

IEEE Symposium on Microelectronics, Chase-Park Plaza Hotel, St. Louis, Apr. 13-15.

Institute of Environmental Sciences, Annual Technical Meeting and Equipment Exposition, Sheraton Hotel, Philadelphia, Apr. 13-15.

American Power Conference, sponsored by IEEE and Illinois Institute of Technology, Sherman Hotel, Chicago, Apr. 14-16.

IEEE and ASME Intrenational Conference and Exhibit on Aerospace Electro-Technology, Westward-Ho Hotel, Phoenix, Ariz., Apr. 19-25.

ASTME Annual Meeting, Convention and Exposition, Detroit, Apr. 20-24.

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The Revolution: Part II

WE DISCUSSED last week the revolutionary impact on the missile/space industry which will result from the shift in military emphasis from strategic to tactical systems. Closely linked to this is the evolving acceptance by the military services of Secretary McNamara's reorganization of the Pentagon.

This acceptance is by no means complete, but there is such strong indication of a new mood in the Pentagon that it deserves comment.

There can be no denial of the fact that the arrival of Mr. McNamara on the scene was greeted with less than all-out enthusiasm by the men in uniform in the Dept. of Defense.

A number of civilian secretaries previously had tried to cope with the Augean task laid down by Congress when it decreed that there should be unification of the massive but thoroughly divided structure of the military establishment.

The leaders of the Air Force, Army and Navy had an unquestionably fine record behind them on the field of battle. They could point with pride to new projects in development which indicated a thorough-going awareness of current military need, and they could overwhelm any civilian organization with their knowledge of strategy and tactics.

"We know better than anyone what is needed to fight a war," became an accepted statement of fact that usually ended arguments concerning hardware.

The Air Force in particular, toughened by its battle for separate recognition and its victory over the "battleship admirals" of the Navy, was riding high. With the vociferous Air Force Association stridently backing its demands, the newest of the services moved into a position of complete dominance.

Its B-36's, B-47's and B-52's were effectively keeping the peace. Its cigar-chewing Gen. Curtis LeMay not only welded Strategic Air Command into one of the most effective military units of all time but made himself a public hero while doing so. Its jets had written a brilliant new chapter in fighter warfare over Mig Alley. To top it off, the Air Force had walked off with the strategic missile assignment in a head-on clash with the Army.

Little wonder then that a civilian Secretary of Defense regarded the junior service as the most awesome of the three he was expected to subordinate. The Navy and the Army, however, continued to give a good account of themselves when it came to bucking civilian domination of the Pentagon.

It should be understood that the high officers in the Pentagon, without exception, acknowledged the need for civilian control of the military establishment. But in most cases it was felt that this civilian authority rested across the Potomac, on Capitol Hill and in the White House, and most certainly was not required to make its presence felt in the halls of the Pentagon itself. The actual running of the military establishment, it was agreed, most properly belonged in the hands of the military.

Then Robert S. McNamara became Secretary of Defense. This changed the name of the game. For the first time, the military services were dealing with a man capable of doing just exactly what Congress had instructed him to do—unifying the Pentagon into a single effective military establishment.

He ran immediately into service opposition. But McNamara was well aware of the powers with which Congress had armed him and he proceeded to use them most effectively, employing management techniques brought with him from industry. Backed by such able assistants as Comptroller Charles Hitch, he pushed quickly ahead with cost effectiveness programs, unified procurement in selected areas, and instituted other financial reforms which the services found difficult to resist—as much because of the logic of the reforms as because of the unquestioned power of the Secretary to proceed in this direction.

One of the most effective of the new McNamara management techniques was the organization of the Pentagon's fighting strength in terms of program packages. This now well-known approach meant, for example, that all strategic programs of the various services were regarded for budgetary, developmental and operational purposes as a single package —that is, *Polaris* submarines were considered simultaneously with Air Force B-52's, *Skybolts*, and the ICBM's.

Almost instinctively, the services resisted this, partly because the overwhelming clarity and logic of program packaging made it all too evident that some projects already in existence or in the planning stage actually were surplus to the nation's military needs. McNamara swung the budget axe vigorously.

During this period, the new Secretary proceeded to present his case on the Hill and in the White House with such clarity and such devastating financial detail that any effort of the military chiefs to appeal to these sources met with little success.

AS THE SERVICES found themselves forced to acknowledge the success of the McNamara reorganization, first in the financial area and then to a lesser degree in the technical area, they also found themselves forced more and more to their only remaining high ground: "We know better than anyone else what we need to fight a war."

Here, initially, there was some logic on the side of the services. There was, and still is, some concern as to whether the Directorate of Defense Research and Engineering is capable of nurturing, selecting and bringing to operational fruition the hardware the military needs to fight future wars. The hardest battle of all was, and still is, fought in DDR&E.

In recent months, however, knowledgeable elements in the services have begun to work more closely with DDR&E. For good or bad, the McNamara reorganization is here to stay. Therefore, most agree, the best thing to do is to play the game by the new rules. The importance of this to industry should not be underestimated.

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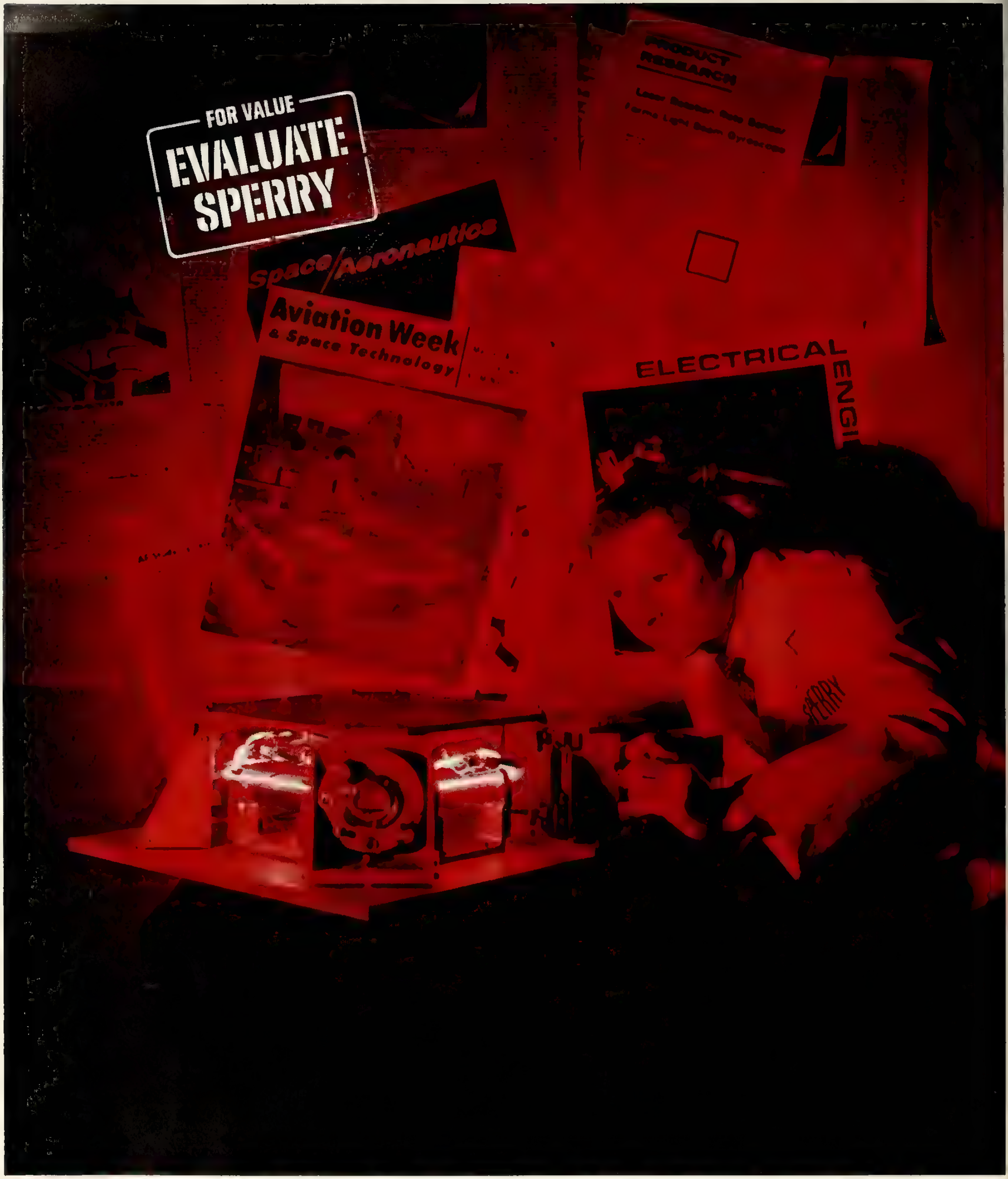
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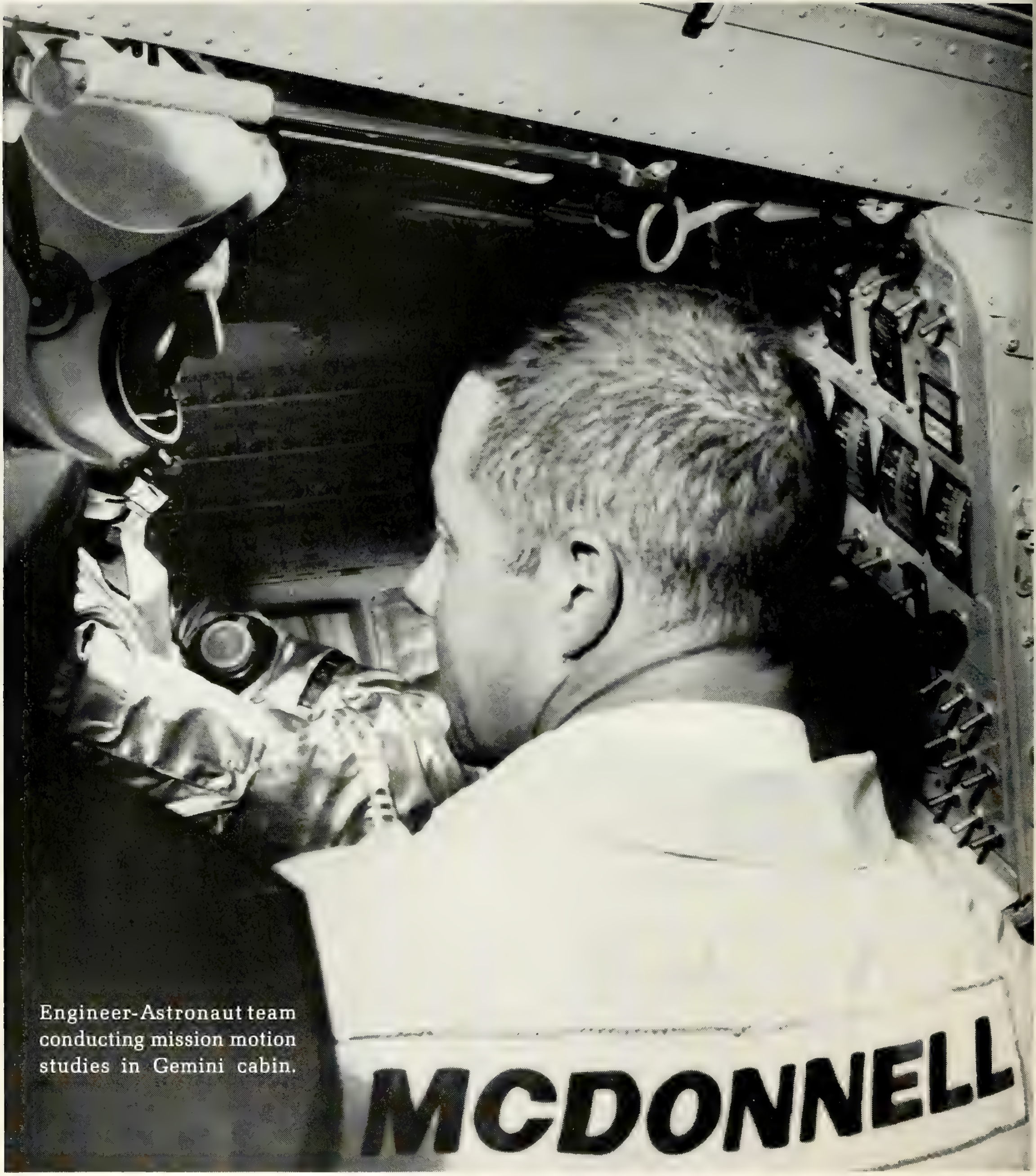

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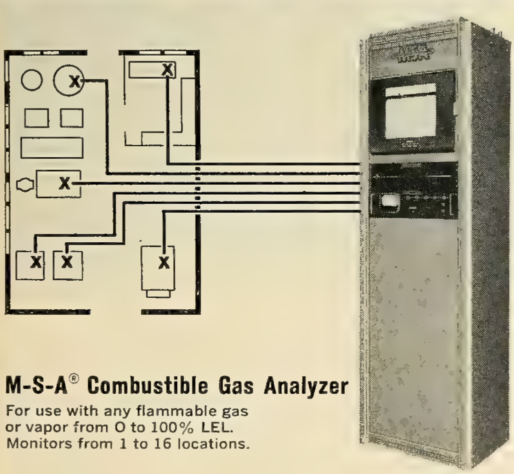

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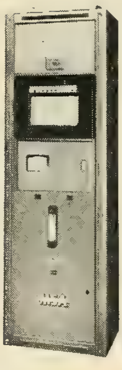

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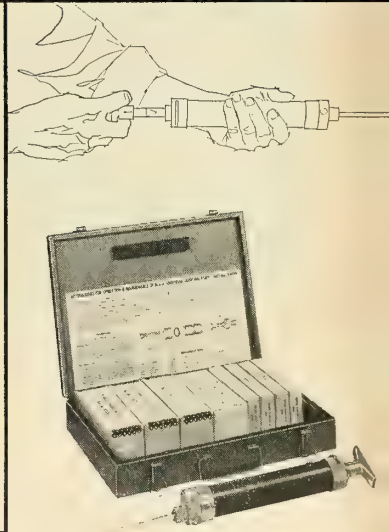

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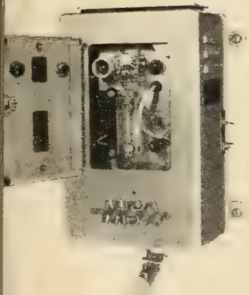

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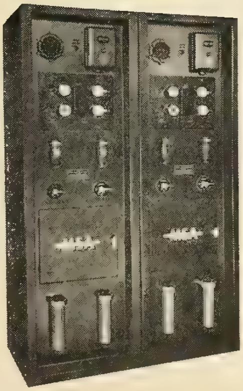

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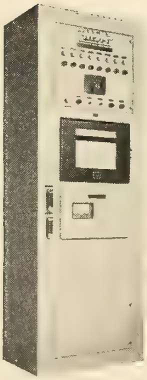

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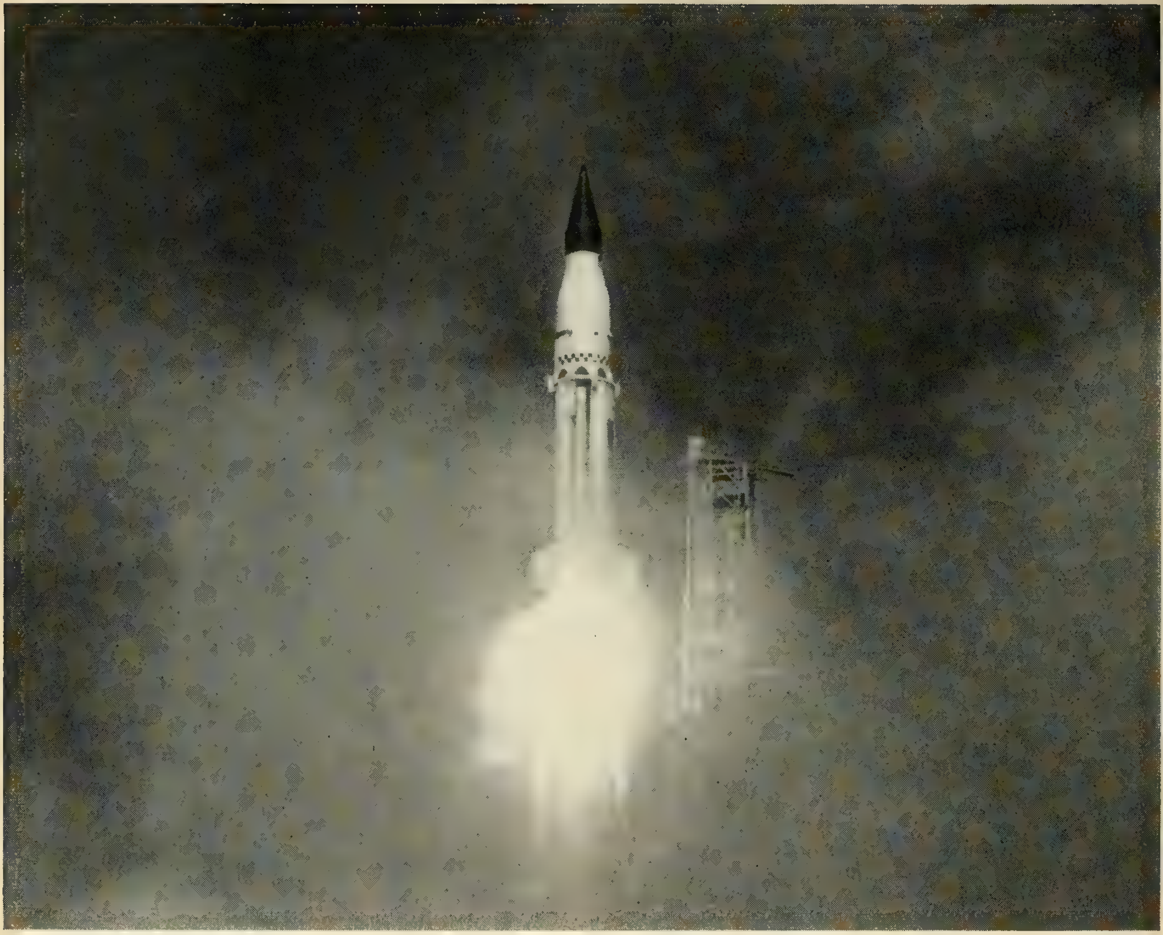

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missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING

Volume 14, Number 15

April 13, 1964

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THE COVER

Gemini/Titan-1, the first unmanned launch of the two-man McDonnell capsule by the Martin Titan II, lifts off Launch Complex 19 at Cape Kennedy April 8. The shot was described as a "story book" flight, boosting chances for a manned Gemini orbit before the end of this year. See M/R's special report beginning on p. 12.

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letters

Rand Role in ECAC

To the Editor:

I noted your article on the tri-service Electromagnetic Compatibility Analysis Center ("Two Documents will Assist ECAC in Solving Military RFI Problems," M/R, March 9, p. 17). I thought you might be interested in knowing that ECAC is an outgrowth of work originally performed between the years 1952 and 1959 at The RAND Corporation, Santa Monica, on problems of signal interference in Europe and the United States, and the effects of such interference on operational systems. In particular, the concept of an electromagnetic compatibility center is largely due to A. L. Hiebert, and the present existence of an ECAC is a credit not only to his original research but also to his persistence in bringing the problem to the attention of government authorities.

The philosophy of operation and detailed technical planning were stimulated to a great extent by Hiebert, who served as scientific advisor in establishing the Center.

Brownlee Haydon
Communications
The RAND Corp.
Santa Monica, Calif.

Defending Alma Mater

To the Editor:

The editorial in the March 23 M/R ("Alma Maters or Madams?") reads as though it had been hastily written by an irresponsible junior on your staff, rather than by you.

From the smart-aleck title thru the outdated, fragmentary and inconsequential statistics to the unwarranted singling out of MIT and Cal Tech for attack, your writer's deceptive generalities are most unworthy of a "spokesman for the industry."

The sweeping generalizations of your writer's peroration are reminiscent of the McCarthy hearings, as they damn all universities with immoral guilt by association. Of the two outstanding institutions attacked, I have factual knowledge of only one. I believe that a careful inquiry will show that your writer's loose charges against the Massachusetts Institute of Technology are totally unfounded.

Don't you think you should tender a telegram of apology to its respected President, Dr. Julius A. Stratton?

Dabney H. Maury
MIT 1922
Sunnyvale, Calif.

Cost of Cost Reduction

To the Editor:

In your editorial, "The Cost of Cost Reduction" (M/R, Feb. 24), the Administration's present approach to cost reduction in the aerospace industry was viewed with alarm.

This concern would be justified if the majority of deductions and assumptions expressed were valid. Fortunately, they are not.

Please remember that the aerospace industry grew quickly, under its prime objective of developing and producing an effective retaliatory weapons capability in the shortest possible time. Time was of prime importance then—*not* costs.

In these early days, the state of the art necessitated use of cost-plus-fixed-fee contracts. These, in turn, tended to relegate industrial economy measures to a secondary role in our race for weapon and space superiority.

Industry has recognized this, and, in its quest for profit improvement, has established cost reduction programs to increase profits through elimination of *unnecessary* costs.

Long before the Administration's request for frugality, value engineering organizations had sprung into operation throughout industry. Current Administration attempts to add momentum to existing industrial cost reduction efforts are part of an obligation—in the Administration's role as customer—to obtain full value in goods and services received.

Nowhere in the Administration's recent communications to industry do I find the implication of gross negligence within the industry which you emphasize.

DOD's seven pages of guidelines merely propose minimum cost reduction program criteria. Emphasis throughout is placed on DOD's intent to rely upon, and fully utilize, the contractor's present internal management system for planning, executing, validating and reporting results.

While reporting methods proposed may appear excessive in most cases, adequate control of a contractor's internal cost reduction program will require greater currency than the semiannual interval suggested.

The law of diminishing returns may apply in cost reduction efforts, but cannot logically be cited as a reason to de-emphasize cost reduction, as you imply. An athlete can overtrain and become less efficient, but seldom does he use that possibility as an excuse to de-emphasize training and restrain enthusiasm.

Your allusion to "clever" management as necessarily unethical is completely unfounded—indeed, somewhat imprudent. At General Dynamics/Astronautics, for example, claimed savings are audited for validity by our Internal Audit Department, thus precluding any possible attempts at "artificial cost cutting."

Industry's goal of profit improvement through pre-eminence in cost avoidance and cost reduction has received major impetus through the Administration's entry into, and enthusiasm for, cost reduction programs.

Knowledge that it is dealing with a "careful shopper" can hardly compromise industry's incentives to profit in a free enterprise system.

W. J. Ridge
Cost Reduction Staff
General Dynamics/
Astronautics
San Diego, Calif.

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The Countdown

WASHINGTON

No Extra Gemini Pad Just Yet

NASA has dropped plans for a second *Gemini-Titan II* launch pad at Cape Kennedy. The Air Force has concurred in the decision despite its plans to use *Gemini* as a supply vehicle for the *Manned Orbiting Laboratory* (*MOL*).

New DOD Tracking Station Operating

A Defense Dept. tracking station has been established and is now operating in the Seychelles Islands in the western Indian Ocean—some 1,000 miles northeast of Zanzibar, where a NASA tracking station is being closed at President Johnson's orders (see p. 11). Because of the location of the new DOD station, however, there's a major communications problem between it and the rest of the DOD network. A special hard-line communications system will have to be installed on the island before full use of the station can be made. Meanwhile, there are unconfirmed reports that a U.S. tracking ship may be sent to the Zanzibar area to replace the closed station.

Lewis Looks for Propulsion Facility Builder

Lewis Research Center is asking for bids on construction of its Space Propulsion Facility. The installation, to be completed early in 1967, will be used for evaluation and development testing of complete spacecraft, as well as nuclear-electric power generation and propulsion systems.

MOL Will Utilize In-Orbit Assembly

Air Force plans for *MOL* include assembling a number of the manned laboratories to make them very large experimental stations. At present the estimated lifetime of *MOL* is from 40 to 70 days. But AF planners expect to add a propulsion system to the large laboratory to keep the station in its intended orbit and operating indefinitely.

Hunter Leaving Space Council

Max S. Hunter, a member of the National Aeronautics and Space Council's staff, is leaving on April 17. He is accepting a position with Bellcom—NASA's systems engineering group for the *Apollo* program.

Committee Sticks to Moon Target Date

A resolution to extend the national deadline for getting a man on the Moon from the end of this decade to "before 1975" is expected to die in the House Space Committee. Chairman George P. Miller (D-Calif.) says he hasn't been asked to take action on it, and he sees no reason for calling it up.

INDUSTRY

STL Studying Mid-Course Detection

Space Technology Laboratories, under contract to the AF System Command's Ballistic Systems Div., has determined that ballistic vehicles can be spotted during the mid-course phase of flight through detection of the rarefied residue accompanying the vehicle. Solar radiation will be scattered by this gaseous residue and can be detected. Two systems—a satellite-based downward-looking detector operating in the ultraviolet range and an airborne system operating at altitudes of 25-30 kilometers in the visible or near-ultraviolet range—were studied.

Boeing Saturn V Share Nears Half-Billion

A $5,943,930 contract modification providing for additional mission support in the *Saturn V* first-stage rocket manufacturing program has been awarded by NASA to the Boeing Co.'s launch systems branch. It calls for further research, development, documentation, quality assurance and mission planning. The supplemental agreement increases the total value of Boeing's *Saturn V* work to $463,711,368.

SSD's New Home Strictly Private

Spokesmen for the Air Force Systems Command's Space Systems Div. want to clarify an item ("SSD Move May Celebrate 10th Birthday") in the March 30 COUNTDOWN. They want it understood that SSD will *not* share its new El Segundo site with Aerospace Corp. The new facility will be "totally and exclusively" SSD, even though it "just so happens" that Aerospace has set up shop across the street.

INTERNATIONAL

Franco-Pakistan Space Pact Reached

France and Pakistan have signed an agreement to cooperate in space research. As a consequence, the Pakistan Upper Atmosphere and Space Research Committee (SUPARCO) will work closely with the Centre National d'Etudes Spatiales (CNES).

AF May Yank Saigon Metsat Station

The first weather satellite read-out station to be set up in support of a combat operation may be withdrawn if *Nimbus* doesn't provide better pictures than those now being received from *Tiros VIII*. The station was set up at Saigon's Tan Son Nhut airport last December, primarily for use with the *Nimbus* satellite due to be orbited this spring It is part of a program in which Air Force weather forecasts are relayed to U.S. and Vietnamese intelligence officers to aid in planning operations against the Viet Cong. However, interim trial exercises with *Tiros VIII* have so far yielded no operational success. In the first few weeks, appropriate grid overlays for identifying picture locations in Viet Nam were not available. When they arrived, local radio interference problems cropped up and voice transmissions were jamming the satellite frequency. Before this interference began, pictures were identifiable but accuracy was marred by a scalloping effect apparently caused by *Tiros VIII* spinning. This would not be a factor with the Earth-oriented *Nimbus*.

The Missile/Space Week

AADS Competition Narrowed

Hughes Aircraft Co. and Radio Corp. of America have been selected by the Army to develop high-risk components for the *Army Air Defense System-1970's* (*AADS-70*). Eliminated from the competition was Raytheon.

The three firms had been conducting tradeoff and cost/effectiveness studies for the Army Missile Command over the last several months. The results of these studies were presented to the Army staff March 30 and the Hughes and RCA approaches were selected for further development.

Teamed with Hughes are Douglas Aircraft Co. and FMC Corp. Beech Aircraft Co. is the other principal member of the RCA team.

The 15-month contracts will concentrate on specific components in critical technical areas—principally target acquisition and missile guidance systems—with sufficient system engineering to provide a basis and direction for the component development effort. DOD budget for FY '65 included $5 million for component development of *AADS-70*. Some $2 million has been spent to date on the program.

AADS-70, which is designed to provide air defense for the field army and to protect *Nike-X* sites from an air-breathing weapon threat, would replace on a "selective" basis *Hawk* and *Nike-Hercules* batteries. One of the principal drawbacks to the system is its high development cost—estimated in excess of the total *Hawk-Hercules* development programs. A combination of complete mobility and an across-the-board capability of coping with any threat to the field army made the original *AADS-70* concept unacceptable from a cost/effectiveness standpoint. The trade-off studies which led to the selection of Hughes and RCA were designed to answer DDR&E cost/effectiveness objections.

IBM Unveils New Computer

POUGHKEEPSIE, N.Y.—The first major redesign of the "basic internal architecture" of IBM computers in a decade was announced here last week by IBM board chairman Thomas J. Watson, Jr.

The result of the three-year development program within the firm is the new System/360, a single computing system spanning the performance range of virtually all current IBM computers, with nearly twice the capabilities of the most powerful computer previously built by the firm.

The system makes major use of new microelectronic circuitry now being turned out at IBM's nearby East Fishkill plant, and is the first "commercially available" data processing system whose design is based upon use of the microcircuits, according to the firm.

Deliveries of the smaller configurations are scheduled to begin in the third quarter of 1965. Larger models will appear in the first quarter of 1966.

In the IBM logic circuits (M/R, Aug. 26, p. 28), silicon transistor and diode active element chips 0.028 in. square and coated in a 60-millionth of an inch thick protective glass film, are attached to a 0.5-in. ceramic substrate, which has the circuit and resistor pattern screened on. Connection of the active elements to the circuit module is accomplished with copper pellets, 0.005 in. in diameter, positioned in holes etched in the glass film and then diffused with solder and conductive metals.

Logic circuit switching speeds in the system range from 300 to 6 nanoseconds, more than twice the speed previously available in IBM computers.

Expansion of facilities at Fishkill to nearly 1-million sq. ft. and the introduction of fully automated manufacturing procedures by next fall are expected to yield an initial annual production rate in the "millions of modules." The modules, while used primarily for the System/360, are also expected to be used in other IBM programs in the aerospace field.

First LLRV Rolled Out

Bell Aerosystems Co. rolled out the first of two Lunar Landing Research Vehicles it is building for NASA at its plant in Buffalo.

The vehicle will be delivered to the space agency's Flight Research Center at Edwards AFB, Calif., this week; however, actual flight tests are not expected before late this summer. In the interim, special FRC instrumentation, telemetry, radar altimeter, Doppler radar, horizontal reference, and special panel displays will be installed and checked. The gimbal-mounted General Electric CF-700 turbo-fan engine, which at full power lifts the LLRV from the ground and at a reduced power setting simulates five-sixths of Earth's gravity, is expected to be installed in June.

Initial flights will shake down the system and test handling capabilities. Second round will simulate lunar landing trajectories through the final 1,500-1,000 ft. of altitude at velocities to 60 mph.

The second vehicle will be completed at Bell next week. It is reported that the LLRV may be modified later for two-man operation.

Two Weapons Plants To Close

By mid-1966 the Atomic Energy Commission plans to close two weapons assembly, modification and repair plants. One is at San Antonio, Tex. and the other, in Clarksville, Tenn.

Part of an AEC consolidation program, the closings are expected to result in savings of $3 million annually, principally through the elimination of about 700 jobs at the two sites. The work will be shifted to plants in Burlington, Iowa, and Amarillo, Tex.

Strike Hobbles Cape

The Army Corps of Engineers says that labor walkouts have caused delays affecting some $110 million of the $250 million in construction work at Cape Kennedy and the Merritt Island Launch Area.

Some 460 ironworkers who had walked off their jobs after their contract with the Patrick AFB contractors association expired at midnight March 31 began returning to work last Wednesday. In Washington, William E. Simkin, vice chairman of the Missile Sites Labor Commission, announced that they were going back to work at the Commission's request pending further efforts to reach a settlement through negotiations in Washington beginning April 9. Simkin said he was hopeful that the high-level talks in the capital would produce an agreement shortly.

Negotiations at the Cape broke down last Tuesday night, after continuous night-and-day sessions. By that time, some 500 additional workers in other crafts had been sent home for lack of work as a result of the ironworkers' absence.

At mid-week, the Corps reported,

three projects at Merritt Island were shut down. These included the Kennedy Space Center headquarters building, the central instrumentation building and the main cafeteria. All were in early stages of construction, and concrete could not be poured for their foundations until reinforcing steel bars were put in place—a job performed by the ironworkers.

The Vertical Assembly Building in the Cape's *Saturn* Complex had been shut down for six straight days. At Complex 39, half of the work on Pad A and the crawlerway was affected.

The Engineers spokesman said the $34.1 *Titan III* construction program was "really hurting badly." Particularly hard hit was Pad 40, one of the man-made "hills" in the Banana River. Work there had to halt at the three-quarter mark in the erection of the mobile service tower—a structural steel construction.

Shots of the Week

NASA's first *Gemini* space capsule was carried into orbit by a modified *Titan II* booster April 8. Launch was from Cape Kennedy's Launch Complex 19 at 11:00 a.m. EST (see story, p. 12).

- Also on the 8th, Air Force Capt. Joe Engle flew NASA's *X-15* rocket plane to an altitude of more than 33 mi. and a speed of 3,477 mph.
- The Air Force on April 7 successfully fired a *Minuteman* ICBM from Cape Kennedy. The 5,000-mi. flight into the South Atlantic was the eleventh straight success for *Minuteman.*
- The Navy's USS Henry Clay successfully launched a *Polaris A2* while submerged off the coast of Florida April 6. The shot was the first launched by the newly commissioned submarine.
- The Soviet Union on April 4 launched *Cosmos 28,* which carried scientific instruments for continued space study.
- An *Atlas-F* ICBM exploded on the launch pad at Vandenberg AFB, Calif. on April 3.
- The Soviet Union launched a space probe called *Zond 1* on April 2.

Navy Dedicates Missile Station

The U.S. Naval Ship Missile Systems Engineering Station was dedicated recently at Port Hueneme, Calif. The new Bureau of Weapons field installation—nicknamed Nemesis—is to provide technical and engineering assistance to the Special Navy Task Force for Surface Missile Systems and the Navy Bureaus in all aspects of Navy ship-guided missile weapons systems.

The station is presently concentrating its efforts on in-service engineering of the 3-T's—*Tartar, Talos* and *Terrier*—and the development of new systems. The station is also participating in the development of standardized maintenance procedures including an integrated maintenance plan for surface missile systems.

Established last July, the station has a complement of 450 military and civilian personnel.

Third MM Wing Operational

The 150-missile *Minuteman* wing at Minot AFB, N.D., was declared operational April 2 in a brief ceremony in which the AF Systems Command turned the complex over to the Strategic Air Command. Under the command of Col. G. F. Friederichs, the 455th Strategic Missile Wing joins Malmstrom AFB, Mont., and Ellsworth AFB, S.D., as operational SAC *Minuteman* bases. This brings to 450 the number of operational solid-fueled *Minuteman* ICBM's.

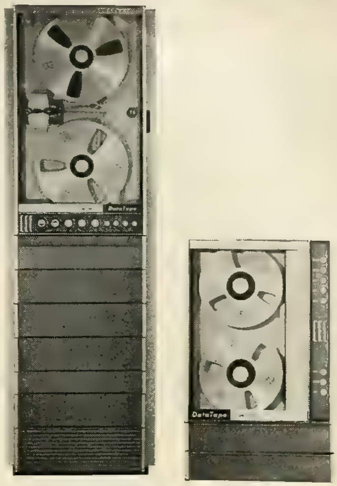
Tracking Station Evicted

President Johnson has ordered the prompt removal of NASA's Zanzibar space tracking station. The decision resulted from a request by Abeid Karume, President of the Zanzibar People's Republic, that the station be moved by the end of April.

Negotiations are underway to relocate the station in the same general area, probably elsewhere in Africa.

Motor Case Exceeds Design

Thiokol Chemical Corp.'s design approach to the 156-in.-dia. filament-wound segmented solid rocket case passed a major milestone when a subscale case hydroburst at 490 psi beyond design limits. The segmented case was roughly the size of the *Minuteman* second stage and was fabricated and tested by B. F. Goodrich. Failure occurred at the center joint at a total pressure of 1,980 psig or an equivalent hoop stress of 372,000 psi. Thiokol's Rocket Operations in Utah designed the metal shim-glass layer joint, which acts like a fully filament-wound connection. All design concepts of the full-scale 156-in. case were incorporated in the 44-in. x 8-ft. test case, and the large chamber winding will start sometime in July. The 156-in. program is part of the Air Force glass case project funded and directed by the Air Force Manufacturing Technology Div. of the Research and Technology Div.



One for the lab and One for the road

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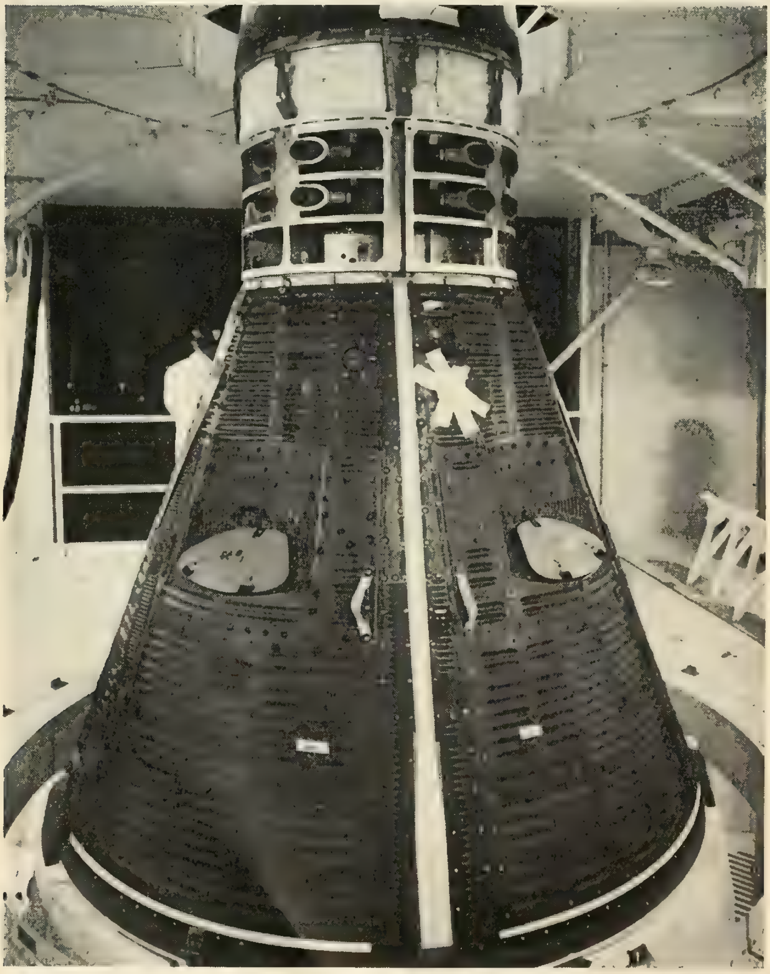
Gemini Gets Off to Good Start

Odds improve for manned flight this year; spacecraft for second, manned flight due for delivery by end of quarter



McDONNELL'S Gemini Spacecraft No. 1 is shown being mated to Martin Titan II launch vehicle at Cape Kennedy. Second craft is now being tested at St. Louis.

CAPE KENNEDY—An almost completely successful first flight of the *Gemini* spacecraft sharply increases the chances for a manned U.S. spaceflight before the end of this year.

GT-1, placed in Earth orbit on April 8, proved the structural integrity of the *Titan II* launch vehicle and its 7,000-lb. *Gemini* payload.

There was also no indication of the "Pogo" vibration problem which plagued earlier *Titan II* development flights and which threatened to delay the *Gemini* program.

A NASA spokesman said the agency was pleased with the *Titan II* performance, adding that "it was well within the limits for manned space flight."

Space agency officials can now turn their attention to full systems testing during the ballistic flight of *GT-2* in August or September.

- **Fighting chance**—The spacecraft for the second flight is now at McDonnell Aircraft Corp., prime *Gemini* contractor, for final checkout and testing. It is slated for delivery to Cape Kennedy near the end of this quarter.

Special Report on Gemini

THIS REPORT on the first launch in the Gemini program was compiled under the direction of NASA Editor Hal Taylor. In addition to the launch story on these pages, it includes (beginning on page 22) articles on the Gemini program schedule, experiments, launch vehicle and launch complex, and spacecraft developments.

If *GT-2* successfully meets its launch date and no technical problems develop, the space agency will have about four months to prepare for the manned flight.

While this is a very tight schedule, NASA officials have a fighting chance to meet it.

GT-1 was hailed as a "story book" flight by Gen. Ben I. Funk, commander of the Air Force Space Systems Division, which was responsible for development of the *Titan II* launch vehicle.

- **One-second slip**—There were no holds for either technical or weather reasons during the long countdown. Lift-off came at 11:00:01 EST, only one second later than planned.

The *Titan II* reached a top velocity of 25,786 miles per hour, about 21 ft. per second faster than planned. As a result, the *Gemini* spacecraft and the second stage of the *Titan II* were placed in an orbit with a perigee of 99.6 mi. and an apogee of 204 mi.

This was slightly higher than the planned orbit of 100-mi. perigee and 185-mi. apogee, but space agency officials said it was well within the acceptable tolerances for the flight.

No indication was given as to the cause of the higher velocity pending review of telemetry data from the flight.

Orbital period for *GT-1* was 89.27 minutes; expected lifetime was 3½ days, plus or minus one day. Telemetry from the spacecraft stopped after the first orbit because the batteries were programmed to provide power for only an hour and a half.

There was no attempt to recover the spacecraft during the *GT-1* flight. The *Gemini-Titan II* combination had a height of 108 ft., with the launch vehicle 89 ft. long and the *Gemini* spacecraft and adapter 19 ft. high.

Its total weight was approximately 300,000 lbs. The spacecraft accounted for about 7,000 lbs. and the *Titan II* for about 293,000 lbs.

- **Steps to come**—*Gemini* has been called the "bridge" between Project *Mercury*, the first U.S. manned space flight series, and Project *Apollo*, this nation's manned lunar-landing program.

The spacecraft is designed to orbit two astronauts for periods up to two weeks, serving as a test bed for systems and subsystems which may be used on the *Apollo* spacecraft, as well as providing a means for the accomplishment of Earth-orbital rendezvous.

The program calls for a total of 12 flights, including two unmanned missions and six rendezvous missions.

GT-2 will be a ballistic flight in which the spacecraft will reach a top altitude of 87 nautical miles and will impact some 1,850 miles down-range. The flight, lasting about 19 minutes, is designed to qualify the spacecraft subsystems. Another major objective will be the demonstration of the spacecraft's re-entry heat protection. It also will provide a training exercise for recovery methods and forces prior to the *GT-3*, the first manned flight.

GT-3 will be a relatively simple three-orbit mission. Planned orbital parameters are a perigee of 87 miles and an apogee of 161 miles.

- **Crewing up**—Space agency officials told a press conference shortly after the *GT-1* flight that the two-man astronaut team for the first flight will be selected in a few weeks.

The team could be selected from the group of astronauts who played important roles in *GT-1*. They include the capsule communicator, Tom Stafford, and Frank Borman, who served as the Malfunction Detection System (MDS) console monitor.

Four of the original astronauts—Virgil "Gus" Grissom, Walter Schirra, Donald K. Slayton and Alan Shepard—were inside the mission control center. Other astronauts were briefed on the flight by Neal Armstrong, one of their number.

- **Tracking**—*GT-1* was tracked successfully by six network stations participating in the flight. The stations are located at Cape Kennedy; Bermuda; Australia; Point Arguello, Calif.; White Sands, N.M.; and Eglin Air Force Base, Fla. For the later manned flights in the program, all of the 18 tracking stations in the network will be used, including two tracking ships. ■

(*Special Report continues on page 22*).

"BRAINS" of Gemini-Titan II launch vehicle shown being assembled at Martin-Baltimore. Second-stage package includes radio guidance, Malfunction Detection System (MDS) units, batteries for power during orbit and flight control system.

House subcommittee told . . .

Titan III Buy Must Be Decided To Avoid Cost Hike, Reliability Drop

by James Trainor

DEFENSE OFFICIALS must decide by the third quarter of this year the number of *Titan III* Standardized Space Launch Vehicles to be produced if they are to avoid increased unit costs and a reduction in system reliability.

If a production go-ahead is not received then, Robert B. Demoret, program manager for *Titan III* applications and growth told a Congressional subcommittee, "many talented personnel will be lost and production line equipment may be moved or modified."

Equally critical, Demoret stressed, were the long leadtimes involved in procurement of components, fabrication of vehicle tanks, final assembly of the boosters and the time required for test and checkout of each flight article.

Unit production costs reportedly are being based on the procurement of a minimum of 25 full *Titan III-C* vehicles. The development flight program consists of 17 vehicles—five core *Titan III-A* configurations and 12 *Titan III-C* versions. First flight of the modified *Titan II* core will take place late this year with the first full *Titan III-C* launch scheduled for late 1965 or early 1966. Core vehicle launches will take place from a converted *Titan I* stand (P-20) at Cape Kennedy.

- **Payload space available**—As part of the flight test program, *Titan III-C* vehicles are scheduled to be launched into low Earth orbits with large payloads, including simulated space stations. These payloads could weigh as much as 25,000 lbs.

Demoret also made a strong presentation of the *Titan III-C* potential for fulfilling NASA missions. Noting that the Defense Department flight-test program requires the launch of several *Titan III-C* vehicles to the vicinity of the Moon to proof-test the system, he pointed out that "these flights could well be used to launch live *Surveyor* payloads to the Moon. This would save considerable money for the *Surveyor* program, since the total cost of the boosters would be borne by the 624A Program" (AF Designation for *Titan III*).

Titan III-C could put 5,000 lbs. into an escape trajectory. *Surveyor* weight is 2,150 lbs. The spacecraft is scheduled to be launched in 1965 by an *Atlas-Centaur*. NASA officials are not too receptive to the suggestion that they use the *Titan III*. They feel that they have all the capability they need for *Titan III*-type missions in *Centaur* and *Saturn IB*.

The flight-test program also calls for several test satellites to be injected into synchronous equatorial orbits. "It is expected," Demoret said, "that one or more active communications satellites will be used during these tests to take advantage of the free ride." Payload capability of *Titan III-C* to 24-hour orbit is 2,100 lbs.

Final tests of the *Titan III* operational capability will consist of launching two full vehicles from the same pad in less than two weeks to prove out the turn-around capability of the Integrate-Transfer-Launch system. Tests of the quick-reaction, long-hold ability of the military space booster will also be conducted.

In his presentation to the House Manned Space Flight subcommittee at the Martin-Denver plant, Demoret argued the case for consideration of the *Titan III* for NASA's *Voyager* mission. "Although *Titan III* is incapable of meeting the full 6,000 to 7,000 lb. payload desired for the *Voyager* mission, it could meet desired instrumentation requirements with two flights instead of one. The low cost of the *Titan III* makes such considerations practical," he added.

- **Growth potential**—In the most lucid presentation to date of the *Titan III* growth potential, Demoret listed several areas in which payload performance could be improved to meet military requirements:

—An increased number of segments in the strap-on 120-in. solid motors in Stage O;

—A new high-energy transtage;

—An increased diameter for the core vehicle;

—Use of thixotropic propellants in the core vehicle;

—Substitution of 156-in. solids for the 120-in. motors.

The present *Titan III* uses two five-segment solid motors. By increasing this number to six or seven segments, the low Earth orbit capability of the launch vehicle would be boosted by about 30% —from approximately 25,000 lbs. in a 100-n.-mi. orbit to 32,500 lbs. The escape payload would be increased from 5,000 lbs. to 7,000—about 40%.

Approximately the same increase in low-orbit performance can be achieved by substituting a high-energy transtage. Improvement in escape payload capability would be more than 100%. DOD has requested $2.5 million in FY '65 "to define the design criteria and performance parameters for a new high-energy upper stage." In addition, about $7.5 million will be spent on advanced liquid engine development. The most promising approaches involve combinations of liquid fluorine and liquid hydrogen or liquid fluorine and hydrazine.

By increasing the diameter of the core vehicle from 10 to 13 ft., structural strength would be added to the overall vehicle, and with greater propellant loading, the low-orbit capability could be increased by 40% to approximately 35,000 lbs.

- **Advantages of thixotropics**—Thixotropic propellants—jellied substances with metallic particles (in this case aluminum) suspended in them—greatly increase the propellant density and specific impulse of liquid engines. By making the *Titan III* oxidizer (nitrogen tetroxide) thixotropic, the low orbit performance of *Titan III* would again be increased approximately 40%.

Finally, by substituting 156-in. solid motors in the zero stage and tailoring the manner in which the thrust changes during burn, the *Titan III* low-orbit capability would be increased 70% and the escape payload by 100%. Controlled burning would minimize the changes required of the core vehicle, Demoret noted. Modification of the ITL complex would be required to handle the larger diameter strap-on motors.

Combinations of these improvements would lead to even greater *Titan III* capabilities. ■

Webb letter precipitates it . . .

House Space Committee Slates Ranger Probe

by Heather M. David

THE HOUSE SPACE COMMITTEE will launch a full-scale investigation into the *Ranger* program and the relationship between Jet Propulsion Laboratory and the National Aeronautics and Space Administration.

The action was triggered by a letter written to the chairmen of the House and Senate space committees by NASA Administrator James E. Webb pointing up a number of criticisms of JPL's handling of the *Ranger 6* spacecraft. Webb told the space committees that "detailed analyses of the *Ranger 6* flight and the associated procedures and tests indicate there were a number of deficiencies in design, in construction and in the testing of this spacecraft."

House Space Committee Chairman George P. Miller (D-Calif.) told MISSILES AND ROCKETS last week that he has asked Rep. Olin Teague (D-Tex.), chairman of the NASA Oversight Subcommittee, to fully investigate the matter. Teague further indicated that Rep. Joseph Karth (D-Minn.) would head the Oversight Subcommittee in conducting the probe. Karth's space sciences and applications subcommittee has regularly handled the *Ranger* program.

- **Karth's approach**—Karth told M/R the investigation would attempt to find out the reasons for the critical NASA report and to establish where the responsibility for the *Ranger 6* failure lies. The report will be the second delving into JPL's handling of the *Ranger* program. The first, the Kelley report, is classified.

The group will compare the two reports to see if the areas of criticism are similiar. Karth pointed out that "some lessons should have been learned and necessary changes made" after the Kelley report.

The space committee heads all emphasized, however, that they would not start criticizing before they get clarification.

Karth indicated that the probe will look closely at the NASA management team responsible for the *Ranger* project. "We must make sure that all the people who have responsibility share in it in both good and bad," he said.

The Minnesota Congressman said that it is very unlikely that any recommendation to shift the *Ranger* program to another group would result, since there are only three spacecraft remaining in the program and they are too far advanced in development to make a switch.

The testing phase will probably receive the most attention. It was specifically mentioned in Mr. Webb's letter and reportedly figures significantly in the Kelley report as being an area needing considerable improvement. Karth said this was "one area where we understood significant changes would take place, and if what we read is accurate, they have not."

- **Motivation a problem**—NASA Oversight Subcommittee Chairman Teague indicated he was interested in seeking out constructive changes that could be made to improve JPL's performance. He said that in general, he favored action that would "strengthen existing ties, and those which would improve JPL performance."

Teague told reporters that the program might be suffering from a "mutual lack of appreciation" between NASA and JPL. He emphasized that NASA needs JPL to accomplish its work.

Chairman Miller told M/R that the issue "points up more than ever the necessity for more and deeper research in the field of electronics, and for the center that has been proposed." Miller said that JPL "should be congratulated on the fact that it could hit the Moon in the area planned" and commended JPL work on the *Mariner* fly-by program.

- **The letter**—Webb's letter to the space committees outlined the findings of the special board directed by Earl D. Hilburn, deputy associate NASA administrator for industry affairs, which reviewed the *Ranger 6* mission failure.

Although the report will remain classified because of technical details relating to vehicles and systems that involve the military, these findings were disclosed:

—"The most likely but not conclusively proven explanation for the failure was an unscheduled turn-on of the television equipment for 67 seconds, simultaneously with the unscheduled turn-on of channel 8 telemetry at the time of booster engine jettison approximately two minutes after launch. . . . Earlier tests indicated that if the TV had been turned on during this time . . . arcing and corona discharge would almost certainly have destroyed both television channels." Webb said, however, that there is some doubt as to the veracity of this explanation.

—"The two video systems were more complex than required and were not completely redundant. They included a number of common components in which a single failure would lead to the disablement of both television systems.

—"The possibilities of failure were increased as a result of practices employed in the design and construction of the spacecraft. Vulnerability to hazards—such as short circuits resulting from foreign particles contacting exposed terminals, a large number of critical control circuits which were routed through the umbilical, unvented and unsealed electronic boxes—was not held to the lowest levels within the present state-of-the-art.

—"During testing, the ground test equipment was linked to the spacecraft by a multiplicity of wires, and thus the tests did not simulate true spaceflight conditions where the only tie between the spacecraft and its ground control systems is through radio communications. It appears possible that these test equipment connections may have obscured potentially dangerous situations which could have enhanced accidental triggering of critical control circuits.

—"The directional antenna required for transmitting pictures from both TV channels was not system-tested with the high-powered TV transmitters.

—"Because of reluctance to risk possible damage to the space vehicle, pre-launch systems verification was not complete. . . . Operation of the entire TV subsystem had not been verified within 12 days of the launch."

Webb said that NASA was finishing detailed plans for modifications to eliminate circuits and components held "most likely" to have caused the *Ranger 6* failure and others potentially vulnerable or least reliable. He said *RA-7* would have a rigorous testing program, resulting in a launch readiness in late June, although no specific date is set. ■

Supplemental in jeopardy . . .

Prospects for NASA FY '65 Fund Restoration Brighten in Senate

SPACE AGENCY hopes for restoration of some funds cut from the Fiscal Year 1965 budget request look promising, but it now appears that the National Aeronautics and Space Administration will receive only about half of its $141 million FY '64 supplemental request.

The Senate Aeronautical and Space Sciences committee is expected to finish marking up the FY '65 authorization bill this week, and in the process should restore funds in several areas deleted by the House Science and Astronautics Committee (M/R, Mar. 16, p. 12).

The minimal size of the initial cut ($110 million) and the probability that the Senate will restore perhaps half this amount, has apparently hurt chances for the agency to receive the full supplemental bill request. "It is generally understood that a good part of the funds they were asking for in the supplemental are provided in the full bill, and that if they got this, they wouldn't need the supplemental," one Congressman said.

- **Senate action**—In considering NASA's budget, Space Committee Chairman Clinton P. Anderson (D-N.M.) said the committee has been very concerned about the NASA propellant program. Sen. Richard B. Russell (D-Ga.) has again been pressing the agency on its plans for the 260- and 156-in. solid-motor programs in the belief that a "hiatus" has set in.

Chemical propulsion has also been a concern, Anderson said. The Senate Space Committee is therefore expected to uphold the House actions in adding $1 million for solid and $3 million for advanced liquid propellant research.

- **Space Sciences**—Anderson indicated he regarded some aspects of the unmanned space probes in the lunar and planetary group as essential, and that he hoped that some of these funds would be restored.

The House cut the *Orbiting Solar Observatory* program by $2.5 million, the *Orbiting Geophysical Observatory* by $6.5 million, and the *Orbiting Astronomical Observatory* by $7 million. *Surveyor*, which was cut $12 million by the House, was described by Anderson as an "extremely effective" program.

NASA has told the committee that it will accept a $5 million cut in the *Lunar Orbiter* program on the basis that procurement could begin with FY 1966 funds.

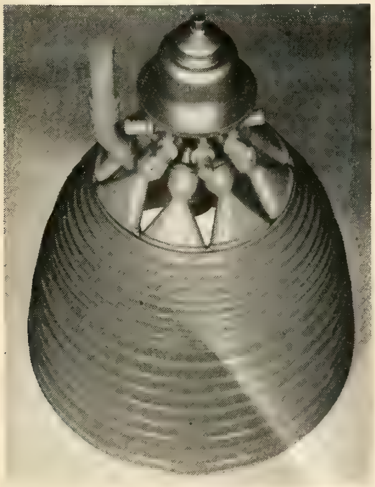
- **The logjam**—While the Space committee will move along on marking up the bill, Anderson said that it would probably be June before the bill can be brought to the Senate floor because of the Civil Rights debate.

The House Independent Appropriations subcommittee has already heard NASA witnesses on the FY '65 appropriations bill, and will start marking up its bill shortly. Staff sources said the subcommittee hopes to get the bill ready by the middle of May.

The House, however, cannot vote on the appropriations bill until the Senate has voted on the authorization and a conference has been held between House and Senate committee members to determine the final amount.

The House Independent Offices subcommittee also has indicated that it will consider the supplemental bill at the same time it considers the appropriations for the next year. The delay brought about by the Civil Rights issue may also contribute to the demise of the supplemental, since the fiscal year may have ended before action can be taken.

In previous years, supplemental requests were handled by a special Deficiencies subcommittee. This year, however, this subcommittee was abolished by House Appropriations Committee Chairman Clarence Cannon (D-Mo.) resulting in a situation in which all supplementals are delayed until consideration of the next fiscal year funds. ■



Aerojet Developing 'Universal' Liquid Engine

A SECOND-GENERATION "Universal"-type liquid booster engine is well into component development at Aerojet-General under Air Force funding from the Rocket Propulsion Labs at Edwards AFB, Calif. The high-pressure engine concept involves a staged combustion cycle which eliminates venting of exhaust products used in the pumping cycles. With chamber pressures in the 2,000 to 4,000 psia regions, the components have been tested on existing Aerojet facilities at the firm's Liquid Rocket Plant, Sacramento, Calif. Building-block approach allows tailoring to any number of specific mission concepts. Current designs are based on existing storable propellants, but both cryogenics and advanced storables can be used. Various altitude-compensating nozzles have been studied, but primary emphasis has been on forced-deflection configurations such as the one shown. In this configuration, altitude compensation is achieved by air passing between the combustors into the center portion. Leading contributor to the new engine is Dr. Rudi Beichel, manager of the Research and Technology Div. at the Liquid Rocket Plant. Best guess at the time for a complete prototype-configuration test-firing is about four years from now—assuming that current funding is maintained. Program funding was not disclosed, but it probably is consuming a major share of the $6.5 million allocated by the Air Force to liquid rocket technology in Fiscal Year 1965 (M/R, March 30, p. 131).

THE PRACTICAL MEN AND THE ROCKET ENGINE Today's giant rocket engines have existed for ages. But only in imagination, for tangible construction awaited a new breed: the practical engineers of aerospace.

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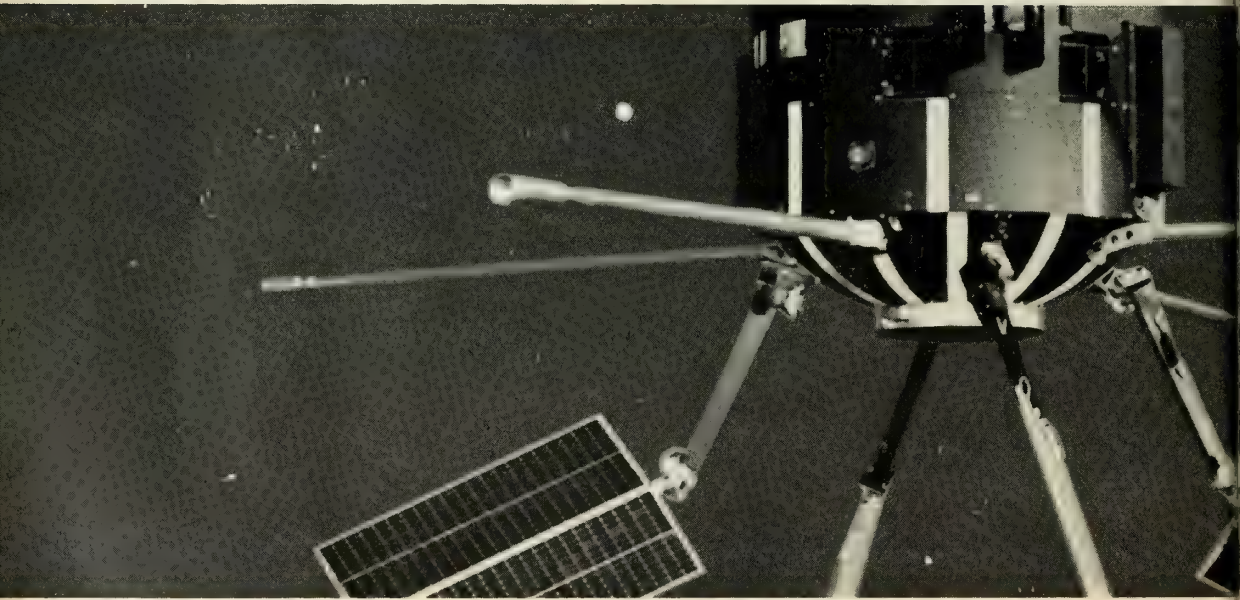

from an international satellite with an assist by Westinghouse

Westinghouse helped build the NASA-coordinated international satellite, Ariel II. It houses three experiments devised by British scientists.

The first will record remote galactic noise from above the ionosphere in the frequency range of 0.75 to 3.0 mc for radio wave analysis.

The second experiment will measure ozone distribution in the upper atmosphere, which meteorologists believe affects the heat balance of the earth.

By measuring the size and flow of micrometeoroids, the third experiment will aid metallurgists in eliminating erosion of spacecraft hulls.

Westinghouse Defense & Space Center helped build the satellite and integrated all subsystems, complete with solar power systems and coding equipment, under the direction of NASA's Goddard Space Flight Center. Ariel II was launched into orbit from Wallops Island, Virginia, successfully beginning its year-long mission in space.

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Technical Countdown

ELECTRONICS

Magnetic Field Affords New Radio Path

Tests with high-powered radar have shown that the Earth's magnetic field can provide a stronger VHF communications channel than meteor trails. When a condition of specularity with the plane of the magnetic field is obtained, two stations can communicate by using the field as a mirror. That is, the angle of incidence of the radiation to the plane of the field must equal the angle of reflection. Studies of this mode of propagation have been carried out by Smyth Research Associates, San Diego, Calif., who have prepared sets of graphs and tables that show conditions for specularity at various points around the Earth. The work was carried out under contract with the Air Force Rome Air Development Center.

Avco Closing MHD-Reactor Gap

A new "hot-electron" magnetohydrodynamic (MHD) generator developed by the Avco-Everett Research Lab has been operated at a gas temperature of 2,900°F and is seen as a significant step toward closing the gap in operating temperature requirements between nuclear power sources and MHD generators. MHD generators have generally required far higher operating temperatures than those available from nuclear reactors. The new generator, which uses a technique of non-equilibrium ionization to produce the "hot electrons" from a gas of comparatively low temperature, is believed to be the first operated at under 3,000°F. New experimental reactors reportedly now can operate at up to 2,200°F. Thus, closing the gap further could lead to efficient mating of the two techniques, still judged to be from 5 to 10 years away, for commercial, military and space power applications. Space use in a SNAP-50 type program would just be marginal, says Avco scientists, reporting that the advantages lie beyond this point into the megawatt range. Avco continues to receive Air Force Ballistic Systems Div. support for the project.

Low-Angle Position Fixing Studied

Feasibility of using radio signals from satellites close to the horizon for position fixing has been studied by Smyth Research Associates, San Diego, Calif. Under a recently completed contract with the Air Force Rome Air Development Center, SRA found that when a satellite is less than 1 degree above the horizon, random errors due to the atmosphere and ionosphere can be quite sizeable. Below 0.5° the angle of arrival of the signal sometimes can not be measured, because atmospheric ducting of the signal takes place. During the tests, the angle of arrival of satellite signals was measured to within 0.1 milliradians (20 arc seconds) by a sea-interferometer antenna at Point Buchon, Calif. Doppler shift of the satellite signal and orbital computations gave an independent means of fixing satellite position.

Solar Wind Origin Modeled

A new theory that evaporation of the solar corona is responsible in large measure for the origin of the solar wind is being developed by Dr. Hari K. Sen, a research scientist in Space Physics at the Office of Aerospace Research-Cambridge Research Labs. Sen evolved a simple physical theory explaining how electrons and protons of the solar winds escape the corona. The key feature is that electrostatic forces balance the solar gravity at a critical altitude in the corona. The result is effectively weightless protons. Sen's formulations show the mass loss to be about 500,000 tons/sec. and less than solar mass losses by radiation. The critical altitude is set at four solar radii and Sen considers only protons. Other simplifying assumptions include a spherically symmetrical corona, steady state outward flow and no effect on flow from coronal magnetic field and rotation.

PROPULSION

Thiokol Cites Propellant Breakthrough

The successful firing of a 1,000-lb. motor containing a high-burning-rate, high-performance propellant and representing a multiple increase in size over any such previous test firing is being termed a breakthrough by its developers, Thiokol's Alpha Div. The predicted level and thrust time trace was obtained in the January 23, 1964, test. The TX-380 rocket motor used a Class II propellant and indicates that the even higher burning rate solid formulations reached in Huntsville lab tests can be incorporated in large motors.

MATERIALS

APT Seminars Scheduled at IITRI

A series of seminars in Automatically Programmed Tools (APT) and numerical control technology will be held at the Illinois Institute of Technology Research Institute in Chicago starting on May 21, 1964. The program will be directed toward manufacturing and engineering executives, production supervisors and technical staff members, N/C part programmers and college instructors. The first seminar will cover symbolic control technology. Other seminars will follow during the rest of the year.

Solar Pressure Attitude Control Studied

The feasibility of controlling satellites through solar pressure is being investigated by scientists at the aerospace division of the Westinghouse Defense and Space Center. Working under funds from NASA's Langley Research Center, the Westinghouse researchers are studying the effect of using special coating materials of varying sensitivity to solar pressure. Satellite solar exposure could be handled through the effects of the Earth's magnetic field on a signal-actuated magnetic coil.

Linde Using Largest Hydrogen Trailers

Liquid hydrogen deliveries to NASA prime contractors in the western states are receiving the cryogenic liquid in 13,200-gallon semi-trailers built by Union Carbide's Linde Division. The trucks route the hydrogen from Linde's 60-ton-per-day plant in Sacramento, Calif. The semi-trailers are 1,000 gallons larger than any comparable over-the-road equipment. The Linde patented insulation limits normal evaporation loss to less than 0.4% of capacity per day.

Six Rendezvous Missions on Schedule

Total of 12 flights planned for project, but it may well become continuous; first two-week manned mission slated for late '65

THE SPACE AGENCY plans to fly six different rendezvous missions in a Project *Gemini* launch schedule expected to extend at least into 1967.

The rendezvous missions, which call for the mating of the spacecraft with the *Agena D* upper stage, are all designed to simulate the docking requirements of Project *Apollo*.

The flights now are slated to end in 1966, but a tight launch schedule calling for four flights in 1965 and five in 1966 is almost certain to slide into 1967.

Rendezvous techniques that will be practiced include combined automatic and manual control, a completely optical approach, an automatic rendezvous completely controlled by the on-board computer and ground tracking stations, direct ascent simulating the *Apollo* lunar mission, emergency rendezvous procedures for *Apollo* astronauts in case of an abort after launch from the lunar surface, and post-docking maneuvers.

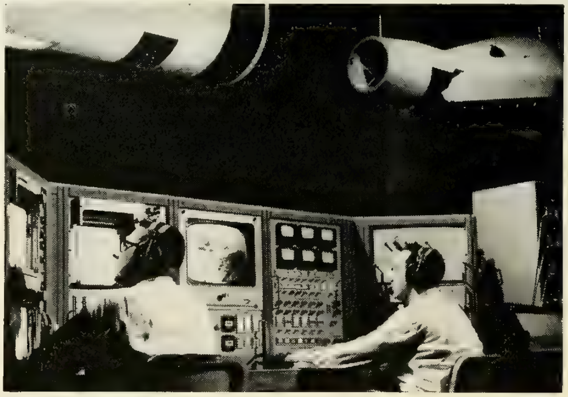
At the same time, NASA officials expect that new requirements developing in the next two years will extend the useful lifetime of the two-man spacecraft into the end of this decade.

This would be in addition to the planned use of *Gemini* as a supply vehicle for the Air Force's *Manned Orbiting Laboratory (MOL)* program in 1968-69.

Dr. Robert C. Gilruth, director of the Manned Spacecraft Center, said recently that the space agency has no plans now to continue *Gemini* beyond the current 12-flight program. He pointed out, however, that when the *X-15* rocket program began nobody foresaw that it would make 100 flights. "It is entirely possible that *Gemini* will be continuous," Gilruth said.

• **Tentative program**—While officials have not yet nailed down the order of the rendezvous and long-duration missions, preliminary plans have been formulated.

The flight program, which began with launch of the *GT-1* spacecraft into orbit last week, will continue in mid-year with the ballistic flight of *GT-2*. Plans call for *GT-2* to reach a maximum altitude of 87 n.mi. The flight will last about 19 minutes and will have a range of approximately 1,850 mi. The flight will have on board all equipment which will be required for manned missions, and will place particular emphasis on qualifying the heat protection and recovery systems. The spacecraft will be picked up by U.S. Navy recovery forces.



DOCKING trainer in which astronauts can practice joining spacecraft with Agena was recently delivered by McDonnell.

GT-3, the first manned flight, is scheduled for late this year or early in 1965. The three-orbit mission, with an 87-mi. perigee and a 161-mi. apogee, will involve the first controlled re-entry test.

Operational missions will get under way in 1965 with *GT-4*, which is scheduled to last four days. The spacecraft will be inserted into an initial orbit of 161-mi. apogee and 87-mi. perigee. Later the orbit will be circularized at 161 nautical miles, which is required for long-duration missions.

Primary purpose of the flight—scheduled for late in the first quarter of 1965—is to investigate the effects of prolonged periods of spaceflight on the astronaut. It may also involve preliminary phases of extravehicular activity, such as cabin depressurization and opening the hatch.

GT-5 will have the same initial orbit, which also will be increased later into the circular 161-mi. path around the Earth. The flight will last seven days, continuing the progressive buildup to a full two-week manned flight. Extravehicular activities will continue and the first rendezvous evaluation test will be made with a pod ejected from the *Gemini* spacecraft.

The first actual *Gemini* rendezvous mission will be made with *GT-6*, slated for the third quarter of next year. Its primary objective will be to prove that rendezvous can be accomplished.

• **Two-step launch**—The *Agena D* will be launched by the *Atlas* booster. Following launch vehicle burnout, the *Agena* will fire and power itself into orbit.

The *Agena* can wait in orbit for the rendezvous maneuvers for about five days, but it is planned to launch *Gemini* in about 24 hours. The launch window for *Gemini*, in order to get it in close proximity to the *Agena*, lasts for several minutes every 24 hours, but it can be extended up to four hours by adjusting the *Agena's* orbit.

According to the determination of the window, the *Gemini* vehicle will be launched. Launch-timing and mid-course corrections will be such that the manned spacecraft will be placed in close proximity to the *Agena* with the *Gemini* vehicle in an 87-161 mi. orbit. The astronauts will control the vehicle in an approach made in accordance with instructions from ground tracking stations and into a terminal docking position with the *Agena.*

As the *Gemini* closes to within 250 mi. of the orbiting *Agena,* the manned spacecraft will be guided toward its target by the astronaut, using the on-board radar and computer systems and controlling the spacecraft maneuvers manually.

Adjustments for the orbital path can be made, in the case of *Agena,* from either the ground control stations or the spacecraft. Similar adjustments will be made for the spacecraft manually—either from the on-board radar information or from ground tracking—in order to successfully complete the rendezvous.

After using the radar system aboard the *Gemini* to close within about 20 mi., the astronauts should be able to see the high-intensity, flashing light aboard the *Agena* for optical tracking.

- **Docking**—The two vehicles, moving through space at some 18,000 mph, will have a difference in speed of one to two miles per hour. Final docking procedures will be accomplished by activating the propulsion units aboard the manned craft for the contact. The spacecraft will use small thrusters of 25 and 100 lbs. of thrust with hypergolic propellants—not the hydrogen peroxide employed for *Mercury* spacecraft. Instruments mounted on the *Agena* docking adapter will permit the astronauts to observe the "health" and safety of *Agena*—fuel pressures, quantities—before making contact.

The astronauts will be able to see the *Agena* straight ahead of the *Gemini* through the flat glass of the windows in their hatches. An index bar of the spacecraft will engage the "V" notch or slot in the docking collar on the end of the *Agena.* The collar area will be fitted with both solid and buffer areas. Upon contact with the cone of the *Gemini* craft—if the match has not started perfectly—both craft will turn slightly and conform. If the *Agena* is bumped away, the astronauts will merely set up for another attempt. Pulse jets will give the *Gemini* a small "kick" at a time.

During the latching part of the docking phase, when clamps inside the *Agena* collar grab the *Gemini* nose cone and pull it into a latched position—the electrical wires will be connected automatically. Facilities aboard the *Gemini* spacecraft will enable the pilot to start the *Agena* propulsion system.

Since the *Gemini* will nose into the collar end of the *Agena,* the *Agena* thrust will be provided from the opposite end; this will cause the astronauts to be propelled backward when using *Agena* power for maneuvering. The "eyeball out" forces will be less than 2 g's and are not considered a problem.

- **Later missions**—*GT-7* will be the first attempt at a two-week-long manned flight. Again the spacecraft will move into the 161-mi. circular orbit. The mission is scheduled for the last quarter of 1965, but slippage into 1966 is possible.

Rendezvous missions will resume with *GT-8,* in early 1966. During this flight, the astronauts will attempt for the first time to achieve the docking maneuver with the *Agena D* without the aid of automatic equipment such as the radar. Approach and hook-up will be under complete optical control of the astronauts.

GT-9 will feature the directly opposite approach—a completely automatic rendezvous using radar computer mode. This consists of the interrogator, which is the rendezvous radar in the spacecraft, and a beacon, the transponder located in the *Agena* target vehicle. Tracking data consisting of range, range rate, elevation and azimuth is provided to the computer. Resultant commands to the propulsion system bring the spacecraft in close proximity to the *Agena.* Final docking will be monitored optically by the astronauts.

GT-10 will mark the first rendezvous missions directly applicable to Project *Apollo.* The flight will utilize the direct ascent mode, in which the *Gemini* will mate with the *Agena* shortly after the spacecraft is inserted into orbit. This mode will be used by the astronauts in the Lunar Excursion Module to dock with the *Apollo* spacecraft's Command and Service Modules, which will be orbiting the Moon.

The next rendezvous test will be flown on *GT-11.* This will practice the LEM abort procedures, including the emergency procedures to be used if trouble crops up and the LEM fails to hook up with the orbiting Command and Service Modules during the first attempt.

The *Gemini* spacecraft and the *Agena D* will be placed in widely different orbits. Both propulsion systems will be used to bring them into orbits close enough to achieve the rendezvous.

The last rendezvous test will practice post-docking maneuvers in which the *Gemini* will disengage from the *Agena* and then attempt to hook up with it again. ■

MAJOR GEMINI PROGRAM CONTRACTORS

SYSTEM	COMPANY	LOCATION
	TITAN II	
Prime	**Martin Marietta Co.**	Denver, Colo.
Guidance	**AC Spark Plug**	Flint, Mich.
Propulsion	**Aerojet-General**	Sacramento, Calif.
	ATLAS	
Prime	**General Dynamics/Astronautics**	
Guidance	**Burroughs Corp.**	Paoli, Pa.
	General Electric Co.	Syracuse, N. Y.
Propulsion	**Rocketdyne**	Canoga Park, Calif.
	AGENA	
Prime	**Lockheed Aircraft Corp.**	Sunnyvale, Calif.
Guidance	**Minneapolis-Honeywell**	Minneapolis, Minn.
Propulsion	**Bell Aerosystems**	Buffalo, N.Y.
	GEMINI SPACECRAFT	
Prime	**McDonnell Aircraft Corp.**	St. Louis, Mo.

MAJOR SPACECRAFT SUBCONTRACTORS

SYSTEM DESCRIPTION	COMPANY	LOCATION
Reaction control and OAMS	**Rocketdyne**	Van Nuys, Calif.
Battery, fuel cell	**General Electric Co.**	West Lynn, Mass.
Fuel cell—reactants supply	**AiResearch Manufacturing Co.**	Los Angeles
Landing systems, parachute	**Northrop/Ventura**	Newbury Park, Calif.
Data transmission	**Electro-Mechanical Research**	Sarasota, Fla.
Magnetic tape	**RCA**	Camden, N. J.
Rendezvous radar and transponder and indicator	**Westinghouse Electric Corp.**	Baltimore
Attitude control and maneuver electronics, rate-gyro-package	**Minneapolis-Honeywell**	Minneapolis Boston
Horizon sensor	**Advanced Technology**	Mountain View, Calif.
Attitude display	**Lear, Inc.**	Grand Rapids, Mich.
Inertial measuring unit, guidance platform, part of guidance system	**Honeywell Regulator**	St. Petersburg, Fla.
Digital computer and guidance system integration (includes manual data insertion unit, part of guidance system, including velocity indicator)	**IBM**	Oswego, N.Y.
Environmental control system	**AiResearch Manufacturing Co.**	Los Angeles
UHF voice t/r		
UF voice t/r		
Voice control center	**Collins Radio Co.**	Cedar Rapids, Ia.
Digital command system	**Motorola, Inc.**	Scottsdale, Ariz.
Retrograde rocket	**Thiokol Chemical**	Elkton, Md.
Ejection seat	**Weber Aircraft**	Burbank, Calif.

Military Adaptability Has Early Priority

Defense Department proposed 10 of 17 experiments scheduled for first three manned flights; GT-2 to probe re-entry blackout

FLIGHT EXPERIMENTS on the early *Gemini* missions are primarily designed to answer the militarily important question of how well an astronaut can observe and photograph orbiting as well as ground-based objects.

Of the 17 experiments to be flown on the first three manned *Gemini* missions, 10 have been proposed by the Dept. of Defense.

The early experimental program also includes a NASA attempt, scheduled for the second unmanned flight this summer, to solve the problem of radio communications blackout during re-entry.

Space agency experiments on the manned flights will probe such areas as visual acuity, Earth field measurements and airglow horizon, Zodiacal light, synoptics terrain and synoptic weather photography. An additional 17 experiments are being considered for flights in 1966 or later.

All of the experiments were proposed by either DOD, private institutions or the NASA Panel on Inflight Scientific Experiments (POISE).

- **Fighting blackout**—Scientific aspects of the program will begin on *GT-2*, with investigation of a potentially useful technique for creating radio windows in the high-temperature plasma surrounding spacecraft during re-entry into the atmosphere.

The experiment was initiated by NASA's Langley Research Center, which proposes to break through the ionized sheath enveloping the spacecraft during re-entry and "blacking out" communications by spraying water into the slip-stream to neutralize the charged particles. The test, in a 70-lb. self-contained unit, will be stowed in one of the aft landing skid wells. Approximately 30 lbs. of water under pressure will be squirted from two nozzles for about 10 seconds.

On *GT-3*, a study will be conducted to determine whether there is any relationship between the effects of weightlessness and radiation on human cells. There also will be an evaluation of the effects of weightlessness on the growth of sea urchin eggs.

The two experiments are called "Synergistic Effect of Radiation and Zero G on White Blood Cells," (POISE 74) and "Effects of Sub-gravity on Cellular Phenomena," (POISE 80).

The military tests will begin with the second and third manned flights, *GT-4* and *GT-5*. Details of the DOD and NASA experiments to be flown on those flights follow:

- **Visual Definition of Objects in Space,** DOD 1. This experiment will study the astronaut's ability to photograph a "selected object" while compensating for its relative motion using spacecraft attitude control. An "off-the-shelf" camera will be used with an optical system "superior" to that used on *Mercury* flights. A special adapter may have to be designed to mate the optics with the camera housing. Equipment weighs 25 lbs.

- **Visual Definition of Terrestrial Features,** DOD 8. An extension of DOD 1 to include Earth objects. This experiment "will provide a comparison of what the man says he can see and what the camera actually verifies."

- **Radiation Measurements.** A dual study by Manned Spacecraft Center (MSC) and DOD 11 is designed to provide basic data through measurements of dose rates in trapped radiation at orbital altitudes, and resultant dosage on biological substitutes for man.

A proton-electron spectrometer will be mounted in the spacecraft to measure proton flux in the lower Van Allen belt, and electron flux in an artificial belt remaining from high-altitude nuclear devices exploded in 1962. Both belts dip into *Gemini's* orbital path over the South America-South Atlantic region. Proton data may verify or modify theories on the formation and behavior of the lower Van Allen belt. Electron data, added to *Mercury* flight measurements, may verify predictions on decay of the artificial belt.

Radiation dosage at several points within the spacecraft will be measured, using tissue-equivalent ionization chambers and scintillation counters. Dosage exposure points simulate surface of the skin and two millimeters below it. Each counter consists of a tissue-equivalent scintillating plastic detector coupled with a photomultiplier tube and a "memory unit." Equipment for this experiment weighs a total of about 25 lbs.

- **Synoptic Weather Photography,** POISE 43, is a continuation of cloud photography performed during *Mercury* flights for the U.S. Weather Bureau. The astronaut probably will use the 70-mm Hasselblad camera with an 80-mm lens to "selectively" take color photographs of cloud formations. The Weather Bureau is particularly interested in tracking cloud systems during subsequent orbits to show their development over a period of time. The camera and film will be stowed in the cabin.

- **Synoptic Terrain Photography,** POISE 92, is an experiment proposed by the Goddard Space Flight Center to obtain high-quality, small-scale photographs of select areas and features along the orbital path for enhancing geology, geography, geophysics and oceanography. The astronaut will probably use the same equipment as in POISE 43 cloud photography.

- **Electrostatic Charge Measurements,** an experiment initiated by MSC, proposes that if an electrostatic potential exists on the surface of the spacecraft, it should be investigated before rendezvous flights are attempted. A high potential built up rapidly through frequent use of thrusters in an environment where "leak off" may be relatively slow could arc on approach of another vehicle. A dynamic electrometer, weighing about 5 lbs., will measure the charge.

- **Radiometric Measurements,** DOD 4, and **Radiometric Observation of Objects in Space,** DOD 9, will be handled as one experiment. The Air Force study is designed to provide basic data on radiant energy from space, specifically "sky background" in the ultraviolet, visible and infrared range. The intensity of radiation emanating from "objects" in space will be measured as a function of wavelength and compared with sky background measurements. The astronaut will make calibrations and scaling adjustments. Special equipment weighing 160 lbs. will be mounted in the adapter, where it will be rotated outward from the sides of the equipment section after the spacecraft is in orbit.

- **Astronaut Visibility,** DOD N-1, submitted by the U.S. Navy, and **Visual Acuity,** POISE 41, submitted by S. Q. Duntley of the Scripps Institute, will be combined into one experiment. It explores the astronaut's ability to discriminate ground objects by naked eye from orbiting altitudes. The astronaut will perform tasks in flight which will be compared with carefully controlled laboratory tasks performed before launch and after recovery. The experiment intends to "ascertain how visual capabilities may vary during flight." Optical properties of the target and the atmospheric effects on those properties will be carefully monitored to make the astronaut's visual acuity the only variable to be measured.

Two instruments will be used: a photometer to measure light scatter in the spacecraft window, and a standard vision tester resembling "a pair of bulky, thick snow goggles." The tester has adjustment knobs, similar to vision devices optometrists use to fit lenses. It will be used to determine how small an object can be recognized and at what distance. Equipment weighs 1 lb.

POISE experiments 43 and 92 will be repeated on *GT-5* with a special 70-mm general-purpose camera designed by MSC. This same camera will be used also for the following POISE experiments:

- **Cloud-top Altitude Spectrograph,** POISE 42. The instrument will supply basic data on a new technique to be used by the National Weather Satellite Center of the U.S. Weather Bureau for determining the altitudes of high cirrus and low stratus formations from weather satellites. Oxygen absorption at a wavelength of 7,600 Angstroms will indicate path length of reflected light from cloud tops. By orienting the spacecraft, the astronaut will make vertically aligned spectograms using a small, hand-held spectograph with diffusion grating.

The spectograph is essentially a camera-back fitted with an optical system which disperses the solar radiation sufficiently to record the 7,550-7,750-Angstroms spectral region with a resolution of 20 Angstroms per millimeter on Kodak high-speed infrared film. Several spectrograms will be made of the Sun to determine absorption properties of the spacecraft window. The device weighs about 3.8 lbs.

- **Visual Definition of Objects in Proximity in Space,** DOD 2, will employ the same camera and optical system as in DOD 1 and 8. The astronaut's ability to control and maneuver the spacecraft around a nearby "object" (Rendezvous Evaluation Pod) in space will be studied from the photographs he takes of it. The Air Force is studying the operational techniques which may be required for the "logistics, rescue and/or maintenance" missions supporting its *Manned Orbital Laboratory* (*MOL*).

GEMINI PROGRAM FUNDING

(In millions of dollars)

FY 1962		54.8
FY 1963		288.1
FY 1964		383.8
FY 1965		
Spacecraft	168.9	
Titan II	66.9	
Atlas	19.5	
Agena	24.9	
Gemini Support	28.2	308.4
COST TO COMPLETE AFTER FY '65		185.2
TOTAL		1,220.3

The REP is designed to check out the operation of the rendezvous radar system aboard the spacecraft before the first *Agena* flight. It may be used also for DOD 1 experiment on *GT-4*. The pod carries an L-band radar transponder and two xenon, high-intensity flashing lights, duplicating the equipment aboard the *Agena*. It is stowed in the equipment section of the adapter from which it is ejected to one side and to the rear of the spacecraft, placing it into a lower-energy elliptical orbit with an out-of-plane component. Orbital forces will move the pod down, underneath and ahead of the spacecraft. The REP weighs 70 lbs.

- **Airglow Horizon Photography,** POISE 49, and **Zodiacal Light Photography,** POISE 12, investigate two dim-light phenomena which are best observed outside the Earth's atmosphere. Data an "airglow" will provide further information on the solar-energy conversion processes occurring in the upper atmosphere. Photographs of the Zodiacal light will help scientists to determine the light's exact origin, geometric distribution, and its usefulness in studying solar radiation and flare activity.

"Airglow" appears as a faint band of light several degrees above the Earth's horizon. Present theories hold that it is caused by the excitation of air molecules and atoms by extra-terrestrial energy, presumably the Sun. It consists of a weak continuum in the visible spectrum and has three distinct colors—yellow from the sodium D lines and green and red lines, the latter two being attributed to "forbidden" transitions in the energy states of atomic oxygen. Time exposures on color film will be made using an MSC 70-mm general-purpose camera.

The nature of Zodiacal light is believed to be sunlight reflected from free electrons and large dust particles in the ecliptic plane, distributed outward from the Sun in interplanetary space, or in geocentric orbits about Earth. The astronaut will make a series of time exposures in the ecliptic plane shortly after sunset or before sunrise, holding the spacecraft relatively stable in attitude to capture the faint pyramid of light. Originator Dr. E. Ney, University of Minnesota, is designing and building a special camera to be used for Zodiacal light photography.

- **Tri-axis Flux-gate Magnetometer.** An MSC study, the magnetometer will be operated with the proton-electron spectrometer used in *GT-4* radiation measurements. It will trace the strength and direction of the Earth's magnetic field lines along each of three mutually perpendicular axes at spacecraft position. These values, in turn, will facilitate interpretation of radiation data collected throughout the orbital flights. ■

Titan II Carefully Groomed for New Role

Removal of weapons system restrictions enables gains in reliability assurance; 'Pogo' vibrations now within limits

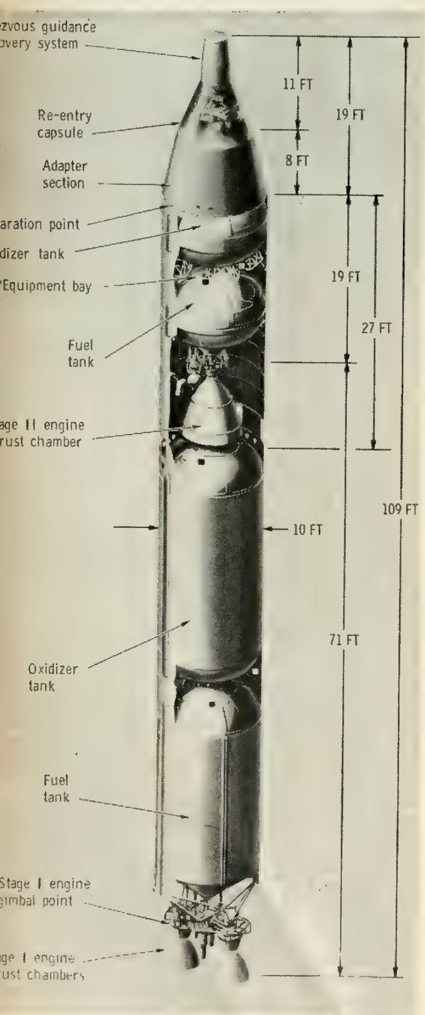


DIAGRAM OF assembled launch vehicle and spacecraft. Equipment bay contents include malfunction detection system, batteries, radio guidance system and autopilot.

A SERIES OF modifications and an intensive reliability assurance program highlighted the manufacturing, testing and pre-launch activity on the *Titan II-Gemini* launch vehicle.

Already a highly reliable weapons system, the *Titan II* vehicle went through an extremely rigid re-examination in its conversion to a man-rated system by its fabricator, the Martin Co., and the *GT-1* launch is still only a part of this approach.

The prime system changes include redundant electrical power and flight control systems, a malfunction detection complex designed to warn the astronauts of launch vehicle failures requiring an abort and the incorporation of the radio guidance system used so successfully on the *Mercury* program.

The elimination of the weapons system aspects posed basic mission differences for the vehicle, and Martin designers were quick to take advantage of them. For instance, the *GLV* is not programmed for long storage in the fueled condition. Elimination of this and other such criteria—no matter how minor—were exploited in raising the reliability assurance factor as much as possible.

Retro-rockets and vernier rockets were eliminated due to the more positive control and guidance systems incorporated throughout boosted flight. There was also a simplification of trajectory tracking requirements necessary for range safety because of the new Missile Tracking Measurement (MISTRAM) system.

The *Titan II* "Pogo," or longitudinal vibration, problem, which made headlines several months ago has been completely solved with respect to the *GLV* —and supplied some basic approaches to the answers to the problem with all liquid rocket boosters. The oscillation amplitude is now below the 0.25-g limit imposed by NASA because of the deleterious effect high forces in this mode have on astronaut ability.

Modifications in this area include the installation of an oxidizer standpipe and a fuel surge chamber or piston accumulator.

- **Powerplants**—The first- and second-stage propulsion systems generate 430,000 and 100,000 lbs. respectively. Both stages use Aerozine-50 and N_2O_4 as propellants. Thrust vector control is through engine gimballing. All are Aerojet-General engines—two in the first stage and the single second-stage.

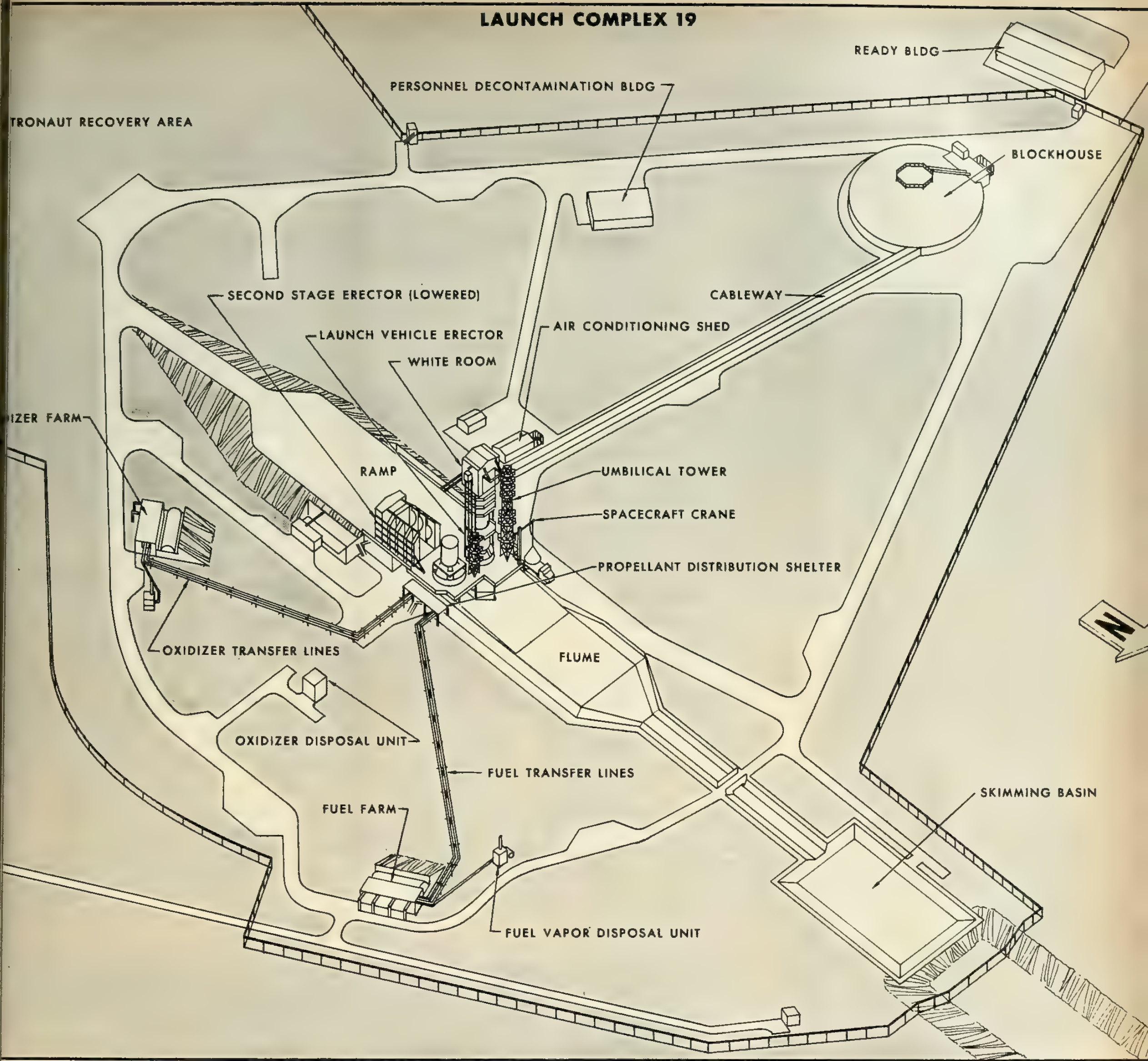
The propellants are hypergolic, with engine starts achieved through solid-charge hot gas initiation. The turbopumps then operate on a bootstrap basis utilizing pump-discharged propellants.

Thrust chamber cooling is handled by circulating fuel in the chamber walls. A dry-jacket start eliminates pre-filling the combustion chambers. A portion of the hot gases generated in the starting sequence is used to pressurize the first-stage fuel tank. Hot gas flow is restrained until the bootstrap sequence is in operation. Propellants are injected in a manner that provides film cooling on the walls of the combustion chamber in addition to the regenerative method.

- **Launch facilities**—The *Gemini* launch area at Cape Kennedy—Complex 19—has a unique launch vehicle erector design. The erector moves the launch vehicle first stage into the launch position from the horizontal and also houses nine hydraulically operated work platforms cradled around the complete booster.

The 138-ft.-high structure is topped by a complete white room, which is environmentally controlled and used to service the upper stage and the spacecraft.

The 140-ton erector is lowered to the horizontal position about 30 minutes prior to the actual launch. The


LAUNCH COMPLEX 19
READY BLDG
PERSONNEL DECONTAMINATION BLDG
TRONAUT RECOVERY AREA
BLOCKHOUSE
SECOND STAGE ERECTOR (LOWERED)
CABLEWAY
AIR CONDITIONING SHED
LAUNCH VEHICLE ERECTOR
WHITE ROOM
IZER FARM
RAMP
UMBILICAL TOWER
SPACECRAFT CRANE
PROPELLANT DISTRIBUTION SHELTER
N
OXIDIZER TRANSFER LINES
FLUME
OXIDIZER DISPOSAL UNIT
FUEL TRANSFER LINES
SKIMMING BASIN
FUEL FARM
FUEL VAPOR DISPOSAL UNIT

entire structure can be deluged with water while in the erect position in case of fire.

The white room is maintained at 72°F and 50% RH and houses four distinct levels. This area alone weighs 25 tons. A five-ton bridge crane is contained within its confines.

A second-stage erector, located next to the large erector, is used only for preliminary checkout or static firings of the upper stage. The 102-ft. umbilical tower feeds signals, power, propellants, nitrogen gas, air conditioning and communications to the entire launch vehicle-spacecraft combination until the moment of launch.

Fuel is pumped into both stages simultaneously, and then the oxidizer is loaded. The operations are sequential. Both ingredients are pumped from nearby tank farms.

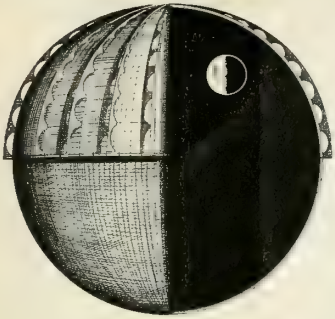
The vapor disposal complex uses electrically driven fans and a 100-ft.-high vent stack to disperse vapors from the vehicle tanks, fuel lines and fuel farms.

The complex 19 blockhouse, located 600 ft. west of the stand, contains the master sequence console on the lower of its two floors. This unit performs a host of checkout and countdown functions that occur too rapidly for manual procedures.

The sequencer has the ability to stop the countdown if an improper or out-of-tolerance response is noted in any system. A large portion of the remaining area on the same floor is taken up with 123 racks, cable terminal boards, cable junction boxes, timing units, switchboards, air compressors and pumps and other equipment.

The second floor houses instrumentation racks and consoles including all aspects of telemetry, landline and recording equipment. Major booster subsystem control and monitoring occupy one section and the remaining area is devoted to spacecraft communication, guidance, aero-medical, environmental controls, maneuvering and the white room TV monitors.

The flight monitoring and separate viewing room for a limited number of dignitaries is also part of the second floor complex. ■



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Spacecraft's R&D Cost Will Top $700 Million

SPACE AGENCY officials estimate that the total research and development cost of the *Gemini* spacecraft will reach over $700 million.

Spacecraft R&D represents well over 50% of the estimated total cost of $1.2 billion for the 12-flight program.

Through Fiscal Year 1965, NASA has earmarked $656 million for the spacecraft. With $187 million set as the funding needed in FY '66 to complete the program, total price tag for the two-man capsule will easily surpass $700 million.

Most of the R&D funds will be spent with McDonnell Aircraft Corp., prime contractor for the spacecraft. The space agency says officially that the contract is worth about $458 million, but it could be higher by the time the program is completed.

Under the terms of the contract, the firm is delivering twelve flight spacecraft. Spacecraft No. 1 was recently launched from Cape Kennedy. Spacecraft 2, 3 and 3a are in final stages of assembly and equipment installation at the firm's plant in St. Louis. Three other spacecraft are now on the assembly line.

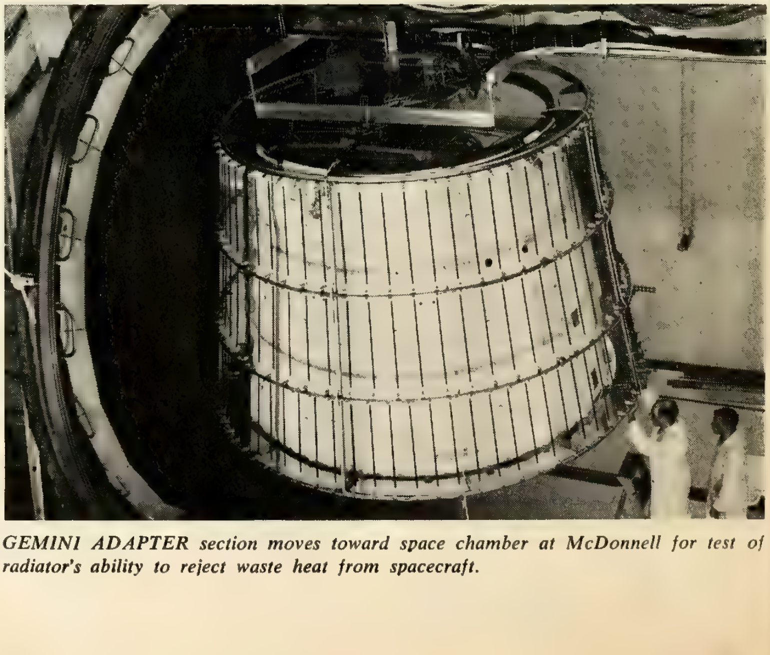
In addition to the flight craft, McDonnell is also supplying 10 non-flying spacecraft, a complete flight quality spacecraft for simulated space missions in an environmental chamber, an electrical systems test unit for integrated testing of engineering models of electrical and electronic equipment, a compatibility test unit, two mission simulators, a docking trainer, three system trainers, nine docking adapters for the *Agena* target vehicle and specialized aerospace ground equipment.

All of the non-flying equipment is scheduled to be delivered by the middle of this year.

- **Contrast with Mercury**—R&D funding for the *Gemini* spacecraft is almost twice the total $384-million cost of this country's first manned spaceflight series, Project *Mercury*.

Gemini, however, is a far more complex and sophisticated space vehicle than the relatively simple *Mercury* craft. It also provides a two-week orbital capability and the opportunity to practice rendezvous missions prior to the U.S. manned landing on the Moon.

The *Gemini* provides 50% more volume than *Mercury* and at 7,000 lbs. weighs about twice as much. *Gemini*



GEMINI ADAPTER section moves toward space chamber at McDonnell for test of radiator's ability to reject waste heat from spacecraft.

will be about 7½ ft. in diameter at the base, as compared to *Mercury's* 6-ft. base diameter. The spacecraft and adapter section have a height of 18¾ ft.

One of the major engineering changes is the inclusion of a space between the outside of the pressurized crew compartment and the external surface of the craft. The area houses instrument packages, electronics gear and landing gear. This construction also serves effectively against micrometeorite damage.

Only the systems directly connected with the crew are housed inside the crew compartment—within the pressurized area. These include the environmental control system, ejection seats, food and waste equipment, microphones, speakers, the three main instrument panels and guidance control.

Use of the modularized approach will cut checkout time for each spacecraft to four months, compared to seven months for *Mercury*.

Another innovation for the *Gemini* spacecraft is an airborne, manual-feed electronic digital computer weighing 57.6 lbs. and requiring only about one cubic foot of space. Designed as a general-purpose, binary and serial machine with a fixed-point arithmetic operation, this computer—under contract by International Business Machines Corp.—is one of the major subsystems for *Gemini* rendezvous and docking missions. It serves as the key system for the complex inertial guidance system. It operates like an IBM 704 and is capable of taking 4,096 bits of programmed information.

- **Adapter**—The adapter section houses the fuel cells, the main oxygen supply, the maneuvering control system and the retrorockets. The section itself is 90 in. long, 90 in. in diameter at the top (base of the spacecraft) and 120 in. in diameter at the lower end (top of the launch vehicle).

Fuel cells are one of the new developments in the *Gemini* program; these will provide the main source of electricity and part of the water supply during orbital flight. The cells combine oxygen and hydrogen to produce electricity and water.

Water from the fuel cells and perspiration collected during the flight will comprise the water supply. Perspiration will be condensed out of the air and will be purified when passed through charcoal for deflavoring of odor. Excess water will be discharged into space via a water boiler.

An array of silver-zinc batteries is contained within the spacecraft to provide power (since the adapter section will be jettisoned) for the re-entry, landing and post-landing phases of the mission. These batteries also serve as an emergency power source, for up to 1½ orbits, during the orbital phase. ■

Power steering in outer space

Yes, in effect that's just what Kidde reaction control systems provide. As secondary propulsion systems they steer space vehicles by making course corrections and velocity and attitude adjustments. ■ Specifically, Kidde's Aerospace Division has developed highly responsive and reliable systems for SYNCOM, ASSET and SATAR. What's more, Kidde designed and is supplying highly successful reaction control equipment for SCOUT and LITTLE JOE II. ■ Kidde can call upon a broad range of capabilities in the development of advanced aerospace systems. Among them are: monopropellant and bipropellant technology . . . integrated cryogenics . . . hot and cold gas valving . . . mechanical and electromechanical actuation. In addition, Kidde offers a broad line of sophisticated and proven aerospace products, a few of which are shown below. ■ For further information call or write Aerospace Division, Walter Kidde & Company, Inc., 420 Main Street, Belleville, N. J.

Kidde

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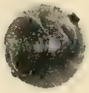
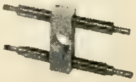


Control valves and thrust motors from 2 to 600 lb.

Ballscrew assemblies for operation under extreme environmental conditions.



Circle No. 7 on Subscriber Service Card

Future Tactical Missiles May Draw on Bullpup Technology

Thiokol beginning second generation liquid engine effort in APPLE program; seeking simplicity with high performance

by John Judge

Bristol, Pa.—Pre-packaged liquid engines will be a strong contender for the propulsion element of future tactical weapon systems.

Using the design, manufacturing and reliability ability acquired in the *Bullpup* series of packaged liquid engines, the Reaction Motors Division of Thiokol Chemical Corp. is developing second generation concepts with improved performance characteristics in a bid for the propulsion sections of the next family of tactical rockets.

An in-house project dubbed APPLE (Advanced Propulsion Packaged Liquid Engine)—started in October, 1963, at RMD—is geared to the establishment of a broad technological base applicable to any next-generation tactical missile.

The main objectives cover advanced interhalogens and hydrazine fuels, total impulse over 200,000 lb.-sec., firing durations greater than 200 seconds, multiple restart during sustainer operation and command termination on both boost and sustainer phase.

In addition there are targets of continuous sustainer throttling (5-10:1), thrust vector control, greater than five-year storage over a —75° to 175°F temperature range, variable demand pressurization and an operational regime covering —65° to 200°F.

There are also high-speed aircraft external-carry considerations involving thermal cycling and the ever-present demand of low RF attenuation.

All of these advanced objectives are to be met without sacrificing the essential simplicity of current pre-packaged liquid hardware.

- **Applesauce**—In outlining these objectives, Arthur Sherman, RMD Director of Preliminary Design compared the current and potential ability of the packaged liquids with both hybrids and solids—with the observation that hybrids lag technically and solids cannot meet some of the thermal cycling standards.

Applied work is being done in engine scale-up. RMD has formulated design and production layouts for engines up to 24 in. dia. The LR62 is 18 in. across and the LR58 is about a foot in diameter.

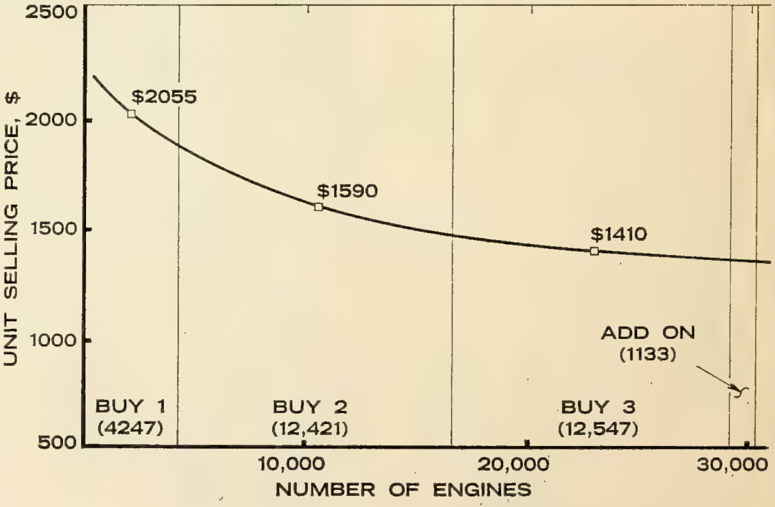
Sherman pointed out that the interhalogen oxidizers and mixed hydrazine fuels do not represent a specific composition but rather a family of propellants—and most are practically off-the-shelf items. Some of the oxidizers include chlorine trifluoride, bromine pentafluoride and other fluoride compounds.

The design expert cautioned against the storable/packageable difference. All pre-packaged propellants are storables but not all storables lend themselves to pre-packaging without compromising simplicity or cost.

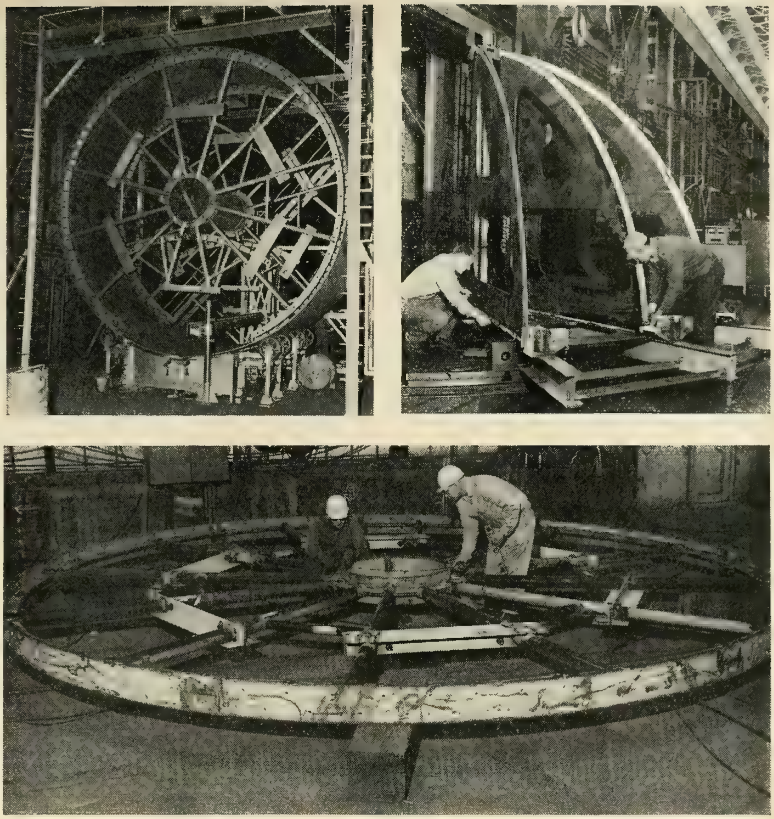
In developing hardware, Thiokol hews to simplicity. Incorporating boost-sustain thrust levels, command termination during both phases, long-duration sustainer operation, positive expulsion and TVC is relatively easy if one can add lines, valves and components to an engine. But to maintain the simplicity at or near the *Bullpup* level of a single moving part poses a much more complex problem.

- **Factory-loaded**—Pre-packaged engine concepts reached design phases almost 12 years ago at Thiokol. The first complete unit, the LR-44, proved the feasibility of the approach and resulted in the *Bullpup* propulsion family.

The *Bullpup A* missile uses the RMD LR58 engine and the larger *Bullpup B* is powered by the 18-in.-dia



TOTAL EFFECT of value engineering approach in the LR-58 engine program.



260-in. Case Shapes Up . . .

THIOKOL CHEMICAL's 260-in. half-length motor case is well into the tooling phases at Newport News Shipbuilding & Dry Dock Co., Newport News, Va. The test cylinder used to establish welding parameters appears at upper left. The dome layout and gore scribing tool is assembled at upper right and the lower photo is one of the collapsible-section inner supports for the maraging steel chamber. Sections of the support ring fold away to allow passage of the welding equipment around the huge cylinders.

RMD LR62. The *Bullpup* is an operational air-to-surface radio-guided missile designed to allow combat pilots time to evade enemy fire while destroying tactical ground installations or moving targets.

Both propulsion elements have only one moving part—a piston-like affair that travels a fraction of an inch to shear off small cups allowing the fuel and oxidizer to enter and mix in the combustion chamber.

The design uses inhibited red fuming nitric acid as the oxidizer and a mixture of amines as the fuel. Both are stored in an aluminum tank shell.

A small double-base solid propellant charge acts as the pressurizing medium. A simple combination injector and initiating mechanism is used. The Martin Co. is the airframe prime on the missile, but sections are actually field-mated by both military customers—the Air Force and the Navy.

All engines are loaded with both propellants at the Thiokol factory. The loading ports are then welded shut and the engine is good for five years or more storage, with handling characteristics similar to solid rockets.

- **Safety demonstrated**—Innumerable drop tests and other handling standards have been met by both the LR58 and the LR62 without incident. In spite of the factory loading aspect, there has never been a fatal accident or injury in the history of the system—either at the fabrication plant or in the field.

With respect to volume, 1,200 early development and production models of all types have been produced. The total number of LR58's produced just passed the 25,000 mark.

The Reaction Motors Div. current output is 1,130 LR58 units a month. Deliveries of the first production units of the LR62 began in December, 1963, and ran at the rate of 300 per month to the total buy of 915. A second buy covering 5,500 LR62 engines is anticipated, with production rates of 670 a month over 12 months.

Harold Davies, RMD Director of Survey and Reliability says a true statistical picture of engine reliability is available on the LR58. On a 90% confidence level and based on a total of 1,420 firings, the reliability figure is 0.9972—a level Davies claims is substantially the same as that for the best solid motors to go operational.

There were only two failures out of the 1,420 firings. One was a vibration level too high during testing and the other consisted of an igniter misfire. The latter missile was safely returned to ground and successfully fired in a later test.

- **Cost cutting stressed**—Throughout the production phases of the pre-packaged liquid engines, Thiokol has pursued an intensive cost-reduction program (M/R Oct. 22, 1962, p. 32.) One example of the detail involved and the savings is the reduction in the cost of the Rokide ceramic coatings in the engines.

In the first buy period of the LR58 unit, the ceramic operation ran to $184.54 per engine. By the time of the current and third procurement period, this figure had been chiseled down to $44.24. Thiokol spokesmen admit this is an outstanding case but the total of all savings in material and processing wrung the cost per engine from $2,055 down to $1,410 in the LR58 program.

There are strong indications that the LR62 pattern will be similar even though it starts at a figure lower than the LR58 on a comparative basis.

Dr. E. H. Seymour, RMD general manager, says the *Bullpup* engine is now price-competitive with comparable solids. In addition, the production line was so set up that there are several industries in the eastern New Jersey area with proven capabilities in producing engine components.

This was developed by Thiokol under the initial Navy contracts and does permit an immediate high-volume response for the engines if the two military services require the weapons in large numbers.

The Army is showing interest in some of the advanced packaged work at Thiokol since the systems can be surface-launched with ease from either ships or land. There is even some indication of future concepts involving on-board TV for visual targeting. ■

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ARC Studying Contaminant Removal

A STUDY TO IMPROVE design of environmental control subsystems for proposed military space stations is being conducted by Atlantic Research Corp.

The Air Force has contracted with the Alexandria, Va., company to find the best means of removing trace contaminants from sealed cabins—a problem receiving increasing attention in both Dept. of Defense and NASA research circles.

Activated charcoal, used in *Mercury* and planned for *Gemini* and *Apollo*, is considered uneconomical for long-term spaceflight, since the canisters become "soaked" and are not reusable.

Dr. Richard H. Johns says his ARC group will study about five materials for use in catalytic burners, which would allow the contaminants to be "burned" and converted to carbon dioxide and water. These products would then be fed into the cabin water and oxygen reclamation systems.

Main areas of study will include palladium-coated asbestos, vanadium pentoxide and oxides of the transition metals such as manganese, copper and iron.

Prime objective of this portion of the work is to reduce the operating temperatures to the lowest possible level and to extend the lifetime. Hopcalite, a material which has been used extensively in submarine work and more recently in space-station simulations at General Electric and the Boeing Co., is considered the state of the art which ARC will seek to improve.

This trademarked material, produced by Mine Safety Appliances, burns at 600°F. The system designed for the *Polaris* submarine research uses about 100 lbs. of the catalyst for a crew of 90-95, and is usable for about six months, project engineer Bart Bartholemew said. At least one of the catalysts ARC plans to study—the palladium—appear to be effective at a significantly lower temperature.

Dr. John's group will begin by making a complete study of Hopcalite and its ability to convert methane. One of the unique points about this study, he says, is that it will provide data not directly related to the size and shape of the burner itself. This information will provide baseline data on which to improve, he said.

Methane was chosen by the researchers as being the most difficult contaminant to remove. They feel that if a catalyst can be found which effectively removes methane, it probably will take care of the others as well. The Air Force has given the company a model space station atmosphere which also includes trace amounts of carbon monoxide, hydrogen sulfide, ammonia, methyl alcohol, hydrogen and freon. All of these are considered likely contaminants.

- **Microbes**—The study will not immediately include investigation of the capability to handle viruses or other potentially harmful microbes, although ARC did design a "virus incinerator" for the National Institutes of Health a year ago.

At that time, according to Bartholomew, it was generally concluded that the control of microbes was a time-temperature problem unaffected by catalytic materials.

No hardware will be produced under the current contract, although ARC has proposed a second phase for development of equipment. The nine-month study was let by the Research and Technology Division of Air Force Systems Command. ■

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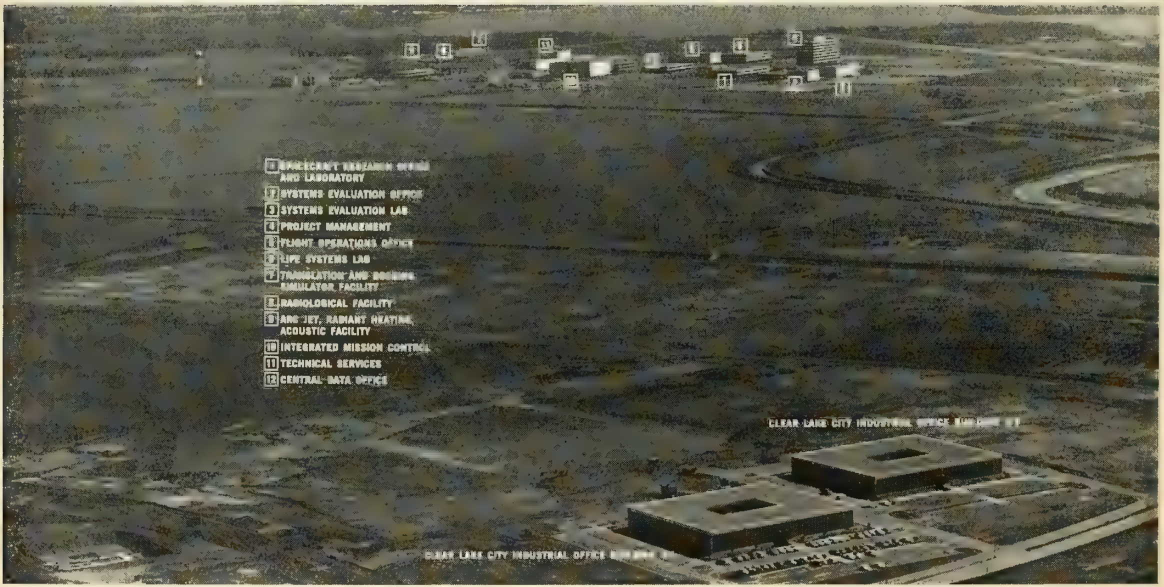
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CLEAR LAKE CITY INDUSTRIAL OFFICE BUILDING I

Photograph taken March 1964

NASA/MSC MOVING SCHEDULE INTO CLEAR LAKE CITY FACILITIES

Feb. 20—Apollo Program office, some elements from Procurement and Public Affairs
Feb. 28—Personnel Division, staff officers, Technical Services
Mar. 6—Dr. Gilruth and management teams, astronauts, Gemini Program office, additional technical and engineering groups
Mar. 11—Flight Crew Support Division, other departments
Mar. 16—Engineering and Development Division
April —Additional electronics groups

Total occupancy by the end of April—2200.

INFORMATION OF INTEREST

LIVING COST Lowest of 20 major American cities (USBLS survey). **LABOR** Houston nation's 6th largest city, over 1900 manufacturing firms with $500 million payroll, extensive pool all levels including highly skilled and technical. **CLIMATE** 60°-74° average (46-64 winter, 75-91 summer). **HOUSING** Clear Lake City residential adjacent, many others nearby. **ACADEMIC** Rice University, University of Houston, 7 other colleges. **TRANSPORTATION** Full-jet facilities 12 minutes away, 60 million cargo-tons through Port and Ship Channel, new Bayport underway. **TAXES** No state or local personal or corporate income, overall state and county $1.87/$100 of 17.7% value assessment. **RECREATION** Year round outdoor, abundant hunting and fishing (salt and clear water), boating, golf, tennis, swimming May to Sept.; National League Colt .45's, AFL Oilers, Domed Stadium '65, college and professional sports, rodeos. **ARTS** Most continuous theatre groups outside New York City. Houston Symphony under Sir John Barbirolli, Grand Opera Assoc., Museums of Natural Science, Fine Arts, Contemporary Arts. **MEDICAL** Texas Medical Center with 10 major hospitals, 3 medical schools, 3 research institutes. **ENERGY** 2.78 million kw capability, large-volume gas priced 20 cents/MCF.

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New Activities

Sigmatron, Inc., has been formed in Santa Ana, Calif., to conduct physical and chemical R & D in the area of vacuum deposition of thin films of material. . . . *The GPL Div. of General Precision, Inc., Pleasantville, N.Y., has expanded its closed-circuit television operations by establishing a new marketing group to handle Government requirements. The new television customer operation will be responsible for establishing and maintaining liaison with new television needs of Government agencies.* . . . McCormick Selph Assoc., Hollister, Calif., explosive ordnance manufacturer, has opened an Electronics Div. in San Jose, Calif. The new division will be part of McCormick Selph's Electro-explosives Department and will give the firm the capability to perform R & D and manufacture entire ordnance systems for missiles, spacecraft and aircraft.

Mergers and Acquisitions

American Bosch Arma Corp. has bought what it describes as "substantially all" outstanding stock of Space Equipment Corp. of Torrance, Calif. Purchase price was not disclosed. Space Equipment manufactures electronics and plastic products. It will be operated as a subsidiary of ABA. . . . *Maremont Corp.'s Rocket Power, Inc., Mesa, Calif., has acquired controlling interest in Cal Val Research & Development Corp., Glendale, Calif. Among Cal Val's products are vibration damping and shock absorption devices for control rooms in missile silos.* . . . Keuffel & Esser Co.'s Optics and Metrology Div. has acquired Kargl Instruments, Inc., San Antonio, Tex. Kargl will function as the Kargl Instrument Plant of K&E and continue producing photogrammetric instruments. . . . *Thompson Ramo Wooldridge, Inc., Los Angeles, has agreed to sell certain of the assets of its Microwave Div., including its VHF coaxial and waveguide switches, to Transco Products, Inc., Venice, Calif.* . . . Fansteel Metallurgical Corp., Chicago, has acquired BMW Manufacturing Co., Inc., Torrance, Calif., industrial metal fabricator and machine tool manufacturer. BMW is to be operated as a wholly owned subsidiary of Fansteel. Move is effort to expand Fansteel's participation in the missile/space, nuclear and chemical markets. . . . *Koster-Dana Corp.'s Liquidonics, Inc., has acquired H. O. Boehm, Inc., New York City, designer and manufacturer of electro-mechanical components and assemblies. Boehm will be operated as a subsidiary of Liquidonics and will be moved to Liquidonics new 35,000-sq.-ft. plant at Westbury, N.Y.*

New Facilities

The University of California at Berkeley has broken ground for the construction of a central building for its Space Sciences Laboratory. The $1,990,000 project is sponsored by a NASA grant and is expected to be completed by late 1965. Facility will include a data processing center, shielded rooms for special electromagnetic studies and spectroscopic work. . . . *General Precision, Inc., has announced plans for a new Computation Center in Pleasantville, N.Y. The Center will perform tasks involving real-time, digital computation for the corporation's Link Group, and for other groups in the company. Initial work will be on simulation projects, including the Apollo-mission simulator.*

International

Ling-Temco-Vought, Inc., Dallas, has reached agreement with the Australian Government Aircraft Factories to market in the U.S. the Jindivik target drone. Jindivik is a near-sonic recoverable target system designed for low-cost evaluation of and training for guided missiles and other air defense systems. . . . *Nucleonic Products Co., Inc.'s Nucleonic Components and Devices Div., Los Angeles, has established a sales and distribution arrangement with the French firm Compagnie Generale des Semiconducteurs to handle its FM drift transistors in the U.S. NPC will distribute the transistors through national representatives.*

Company Representatives

Industrial Electronic Engineers, Inc., North Hollywood, Calif., has appointed E-Squared Representatives, Huntsville, Ala., to handle its line of display devices and accessories in Alabama, Georgia, Mississippi and Louisiana. . . . *National Connector Corp., Minneapolis, has appointed the Frank W. Taylor Co., Inc., Dewitt, Rochester and Utica, N.Y. as sales representative for the state of New York. NC makes a line of standard electrical connectors for the computer, instrumentation, missile/space and aircraft industries.* . . . Electron Products Div. of Marshall Industries has named the G.S. Marshall Co., San Marino, Calif., Southern California representative. Marshall Industries manufactures a line of capacitors in metallized paper, metallized Mylar, polycarbonate and polytyrene film in hermetically sealed, wrap-and-fill and epoxy case configurations. . . . *Marquardt Corp., Van Nuys, Calif., has established two field offices to serve the western U.S. and the New York area. F. C. Morris will head the western office in Van Nuys, Calif.; William F. Hoy will manage the New York office, headquartered in Huntington, Long Island.* . . . Raymond Engineering Laboratory, Inc., Middletown, Conn., manufacturer of electromechanical components and subsystems for the missile/space and aircraft industries, has appointed sales representatives for the southeastern and southwestern areas of the U.S. Named were Gurley Assoc., Huntsville, Ala., and Aztec Enterprises, Englewood, Colo. . . . *Digital Sensors, Inc., Los Angeles, manufacturer of cable assemblies and fabricators of welded-connection flexible electrical connections, has added three technical representatives to its sales force. The new representatives are: Wally Shulan Co., Clifton, N.J.; William Hicks Co., Roslyn, N.Y.; V.J. Huntoon Assoc., Inc., Springfield, Mass.; and the Don Medeiros Co., Mountainview, Calif.*

contracts and procurements

AWARDS

AIR FORCE

$24,600,000—**Cutler-Hammer, Inc.**, Airborne Instruments Lab., Deer Park, N.Y., for work on a classified project.

$12,200,000—**General Dynamics Corp.**, Astronautics Div., San Diego, Calif., for follow-on modification of *Atlas* space boosters.

$11,300,000—**Avco Corp.**, Wilmington, Mass., for design, development and testing of *Minuteman* ICBM Mark II-A re-entry vehicles.

$10,000,000—**The Boeing Co.**, Seattle, for R&D work on improved *Minuteman* ICBM missiles.

$3,200,000—**Douglas Aircraft Co., Inc.**, Santa Monica, Calif., for continued production of launch vehicles.

$2,300,000—**Douglas Aircraft Co., Inc.**, Santa Monica, Calif., for launch vehicle engineering and space booster production.

$1,700,000—**Honeywell Regulator Corp.**, St. Petersburg, Fla., for accelerometers for *Polaris A3* missiles.

$1,500,000—**Yardney Electric Corp.**, New York, for high-energy missile and aircraft batteries.

$1,500,000—**Aerojet-General Corp.**, Sacramento, Calif., for work on solid propellant motors.

$1,400,000—**General Electric Co.**, Syracuse, N.Y., for supply and maintenance of missile equipment.

$1,368,000—**Chicago Bridge & Iron Co.**, Chicago, for design and installation of outer space simulation system at Rocket Propulsion Laboratory, Edwards AFB, Calif.

$1,200,000—**Hughes Aircraft Co.**, Culver City, Calif., for work on *MMRBM* program.

$244,500—**Hayes International Corp.**, Birmingham, Ala., for liquid oxygen semi-trailers.

$50,344—**Electronic Communications, Inc.**, Research Div., Timonium, Md., for six-month extension of experimental investigations with phased-array antennas.

$43,000—**Motorola Semiconductor Products, Inc.**, Phoenix, Ariz., for study of deleterious surface effects on silicon transistors.

$38,515—**Hayes International Corp.**, Birmingham, Ala., for technical data.

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International Telephone & Telegraph Corp., Nutley, N.J., for study of cooling methods for overheated spacecraft (undisclosed amount).

Atlantic Research Corp., Alexandria, Va., for an investigation of catalytic combustion processes applicable to design of catalytic burners for use in destroying trace contaminants in manned orbiting space stations (undisclosed amount).

ARMY

$9,600,000—**Olin Mathieson Chemical Corp.**, New York, for production of various propellants.

$2,400,000—**Thiokol Chemical Corp.**, Bristol, Pa., for production of an altitude simulation system for use at White Sands Missile Range, N.M.

$1,600,000—**Ingraham Co.**, Bristol, Conn., for production of booster parts.

$1,472,870—**Farmer's Tool and Supply Corp.**, Denver, for production of missile shipping containers.

$1,300,000—**Aerojet-General Corp.**, Sacramento, Calif., for research and development on the *Sprint* missile.

$41,890—**Servonic Instruments, Inc.**, Costa Mesa, Calif., for a transducer for use in the *Hawk* missile system.

Martin Co., Orlando (Fla.) Div., a modification providing for product improvement of BIRDIE fire coordination systems (undisclosed amount).

NAVY

$1,700,000—**Goodyear Aerospace**, Akron, Ohio, for continued research and development on the *Subroc* weapon system.

$77,691—**International Electronic Research Corp.**, Burbank, Calif., for development of FM/FM telemetry transmitting system.

$75,000—**Hughes Aircraft Co.**, Fullerton, Calif., for studies to improve radiation simulation techniques.

$54,000—**IBM Federal Systems Div.**, Oswego, N.Y., for research on digital computer flight control systems.

$42,880—**Gulf Aerospace Corp.**, Houston, for a telemetering equipment discriminator system.

$39,651—**Collins Radio Co.**, Cedar Rapids, Ia., for transceivers and antenna couplers.

NASA

$5,500,000—**IBM Federal Systems Div.**, Rockville, Md., for the integration of systems of *Saturn IB* and *Saturn V* rocket instrument units.

$4,800,000—**Federal Mogul Bower Bearings, Inc.**, Arrowhead Products Div., Los Alamitos, Calif., for modification to an existing contract for provision of fuel and LOX ducting for *Saturn V* boosters.

$319,150—**Allis-Chalmers**, Milwaukee, Wis., for electrical drive system for launch phase simulator under construction at Goddard Space Flight Center.

$312,000—**Advanced Scientific Instruments**, Minneapolis, Minn., for two ASI 210 digital computer systems.

$169,800—**Cubic Corp.**, San Diego, Calif., for distance measuring equipment.

$153,600—**Hayes International Corp.**, Birmingham, Ala., for instrumentation support services at Marshall Space Flight Center.

$130,000—**University of Colorado**, Boulder, for solar ultraviolet radiation studies by five physicists at the University Laboratory for Atmospheric and Space Physics.

$94,261—**Monsanto Research Corp.**, Dayton, Ohio, for a survey of space effects on chemical technology.

Westinghouse Defense and Space Center, Aerospace Div., Lima, Ohio, for study of feasibility of using and controlling pressure exerted by solar rays to control Earth-orbiting satellites (undisclosed amount).

INDUSTRY

$2,100,000—**Western Hotels Industry Services, Inc.**, Seattle, from **The Boeing Company**, Seattle, for food service and housing management and maintenance at U.S. Air Force *Minuteman* locations in Grand Forks, N.D.

$1,611,138—**Trans-Sonics Inc.**, Burlington, Mass., from **The Boeing Co.**, Seattle, for in-flight liquid level measuring systems for the *Saturn* SI-C booster.

$1,215,000—**Data Display, Inc.**, St. Paul, Minn., from **General Electric Co.**, Apollo Support Dept., Daytona Beach Fla., for four display systems for *Apollo* spacecraft.

$500,000—**Lear Siegler, Inc.**, Astro Structures Div., El Segundo, Calif., from **Curtiss-Wright Corp.**, Wood-Ridge, N.J., for production for first stage *Minuteman* motor case sections.

$300,000—**Information, Inc.**, Culver City, Calif., from **IBM Federal Systems Div.**, Rockville, Md., for programming services in support of the Real Time Computer Center under development by IBM and NASA.

$148,000—**United Electrodynamics Inc.**, Pomona, Calif., from **The Boeing Co.**, Seattle, for voltage control oscillators and transmitters for use in telemetry systems with ARPA's HIBEX program.

$72,000—**Products Research Co.,** Burbank, Calif., from **The Boeing Co.,** Seattle, for potting and molding compound to be used in the *Minuteman* missile program.

$72,000—**Waterfall Construction Co.,** Ogden, Utah, from the **Marquardt Corp.,** Van Nuys, Calif., for part of the construction of the Air Force-Marquardt Jet Laboratory Hypersonic Propulsion Facility addition at Little Mountain, Utah.

Mechanics Research, Inc., El Segundo, Calif., from **Hughes Aircraft Co.,** Culver City, Calif., for engineering analysis and design studies in connection with the *TOW* missile program.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

National Aeronautics and Space Administration
Langley Research Center
Langley Station
Hampton, Va. 23365

Theoretical study of electron irradiation effects on capacitor-type micrometeroid detectors. NASA is negotiating with Research Triangle Institute, Durham, N.C. RFP L-4352 not available. For information only.

National Aeronautics and Space Administration
Langley Research Center
Langley Center
Hampton, Va. 23365

R&D program for a combined carbon dioxide removal and reduction system. NASA is negotiating with Hamilton Standard, Windsor Locks, Conn. RFP L-4321 not available. For information only.

Headquarters
Ballistic Systems Division
Air Force Systems Command
Norton AFB, Calif.

Division contemplating procurement in FY '65 of technical and engineering services on a sole source basis from TRW-Space Technology Laboratories, One Space Park, Redondo Beach, Calif., in support of non-development tasks associated with the Titan and Minuteman weapon system progrms. No subcontracting contemplated. RFP's not available. For information only.

National Aeronautics and Space Administration
Manned Spacecraft Center
General Research Procurement Office AC82
Houston, Tex. 77058

Accelerometers to be used on the Apollo Earth landing systems. IFB 64-117B. Bids opening 5-5-64. IFB's available through 4-30-64.

Contracting Officer
National Aeronautics and Space Administration
Langley Research Center
Langley Station
Hampton, Va. 23365

Simulator, digital signal, one each. IFB L-4430. Bid opening 4-28-64. Request for IFB should be sent by 4-17-64 and will be furnished to the extent available.

U.S. Army Missile Command
Redstone Arsenal, Ala. 35809

Installation of cooling fans to oscilloscopes, 71 each. Delivery required 6-30-64. Documentation adequate to support competitive procurement of this item is not available and cannot be developed within the time necessary to permit competitive procurement and meet the required schedule. Fairchild-Dumont Laboratories, 750 Bloomfield Ave., Clifton, N.J., is presently producing this item. These reasons proclude award to other than Fairchild-Dumont.

Bureau of Naval Weapons
Washington, D.C. 20360

538 units of electronic assembly Mark II mod 0 for Shrike missile. Bureau of Naval Weapons intends to solicit a proposal from International Telephone and Telegraph Corp., Industrial Laboratories Div., Fort Wayne, Ind. Note: Small business firms and others interested in subcontracting should contact the above firm direct, referencing C/N 4342-64 BuWeps Synopsis No. 648-64.

Contracting Officer
National Aeronautics and Space Administration
Langley Research Center
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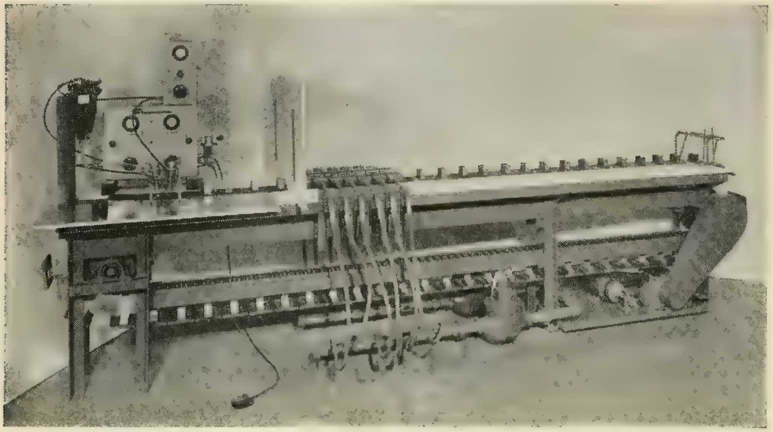
Circle No. 12 on Subscriber Service Card

New Product of the Week: Automatic Silver Brazer



An automatic silver brazing machine to join copper shading coils to solenoid laminations has been designed and manufactured by Fusion, Inc.

The unit is said to provide labor savings up to 75%. According to manufacturers, production is boosted 600% and savings on fuel consumption to heat parts to brazing temperature is significant.

In the system, an in-line conveyor is adapted to the operation. The operator stakes the shading coil to the lamination and places it in a locating fixture below two paste applicators. Two deposits of silver brazing paste are automatically applied. The assembly is then dropped on the conveyor belt where it passes between two rows of high pressure gas-air burners which heat it to the proper brazing temperature (1,150° F).

Total production rate is 360 assemblies per hour.

Circle No. 151 on Subscriber Service Card

Polycarbonate Capacitors

Electron Products Div. of Marshall Industries in marketing a line of metallized polycarbonate capacitors.

The Series H units cover capacitance ranges of 0.001 to 10.0 mfd in 200, 400 and 600v dc rating. Operating temperature is —55° to 125° C. The devices are available in wrap-and-fill, rectangular and round hermetically sealed styles. The rectangular and round units meet moisture resistance, temperature and immersion cycling requirements of MIL-C-19978B.

Circle No. 152 on Subscriber Service Card

Instrumentation Amplifier

An instrumentation amplifier with an adjustable input sensitivity of 2 to 10 mv/v is being marketed by Scionics Corp.

The unit has an output of 0 to ±5v dc. Combined error of non-linearity and hysteresis is less than ±0.2% full scale. Power required is 24 to 32v dc, 35 ±5 ma at 28 v dc; operating temperature range is —65° to 200° F. The thermal sensitivity coefficient is less than 0.01% of reading per degree F. Zero shift is less than 0.005% full scale.

Circle No. 153 on Subscriber Service Card

Desk-Top Analog Computer

A solid-state desk-top analog computer, the PACE TR-20, is being marketed by Electronic Associates, Inc.

The unit has internally packaged resistors that eliminate external resistors and permit programming with bottle plugs and patch cords only. Variable slope/breakpoint function generators and sine/cosine generators broaden the range of problem solving. Other features include an amplifier computing accuracy of 0.01%, a high-speed comparator and electronic switch and four-channel oscilloscope display.

Circle No. 154 on Subscriber Service Card

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SCIONICS

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Circle No. 13 on Subscriber Service Card

Multiplex Switch/Chopper

Two versions of a molecular opto-electronic multiplex switch/chopper, the PEX 3002 and PEX 3003, have been announced by Texas Instruments, Inc.

These experimental functional electronic blocks employ optical coupling between a gallium arsenide infrared source and silicon photo transistors to provide ac and dc isolation between driver and switch. Optical coupling permits sampling rates from continuous dc to 30 kc. With 100v between driver and switch, the dc leakage is less than 0.1 nanoamp.

Electrostatic shielding between the driver and switch minimizes transient noise. A 400-cps sampling rate generates typically 3-microvolts RMS noise. ON impedance of the switch is typically 30 ohms. Offset voltage is typically 20 microvolts at 25°C with a 100-ma drive current.

Circle No. 155 on Subscriber Service Card

Beacon Magnetron

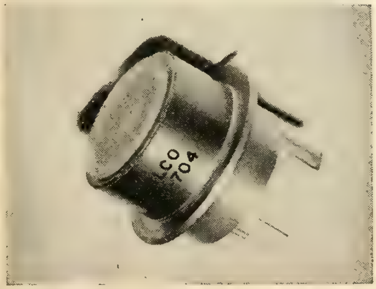
Bomac Div. of Varian Associates is marketing a beacon magnetron featuring an integral load isolator that allows 5 kw of output power from a 20-oz. package.

The Model BLM-153 is a tunable C-band magnetron with an operating range of 5.7 to 5.8 gc. The tube offers 26% efficiency and a pulse duration of 0.75 μsec. Duty cycle is 0.0015; peak anode voltage is 4.8 to 5.2 kv. Peak anode current is 4.5 amp.

Circle No. 156 on Subscriber Service Card

Infrared Detector

Philco Corp.'s Lansdale Div. is marketing an indium-arsenide photovoltaic detector featuring thermoelectric cooling and designed for star tracking, launch detection, missile guidance and fuzing applications.



The Model IAT-704 provides optimum usage from 196° to 235°K. At 233°K, the unit exhibits a spectral response of 1.0 to 3.4 microns with typical D* (500, 900, 1) values of 2 x 10^9 cm/watt and NEP (500, 900, 1) values of 4.5 x 10^{-11} watts. Time constant is typically 1 μsec. Signal response is linear from the limits of detectability to more than 1,000 μwatts/cm^2.

Circle No. 157 on Subscriber Service Card

Recorder/Reproducer

Mincom Div. of 3M Co. has introduced two models of its line of 1.5-mc recorder/reproducers.

The Ticor II features an improved correction of time displacement error. The unit holds time-base correlation between events to within ±0.5 μsec.

The Tidax model provides automatic equalization at all speeds built into each direct record/reproduce amplifier. It has 14 1.5-mc tracks in one rack. Signal-to-noise ratio is 25 db at all speeds.

Circle No. 158 on Subscriber Service Card

Integrated Power Circuits

Two integrated power circuits with a dissipation rating of 25 watts (at T_c= 25°C) and a minimum beta of 1,000 (at 5 amperes) are being marketed by RCA Electronic Components and Devices.

The devices, RCA-2N3230 and RCA-2N3231, employ epitaxial silicon and planar construction techniques and offer the equivalent circuitry of a high-gain amplifier with commutating diode protection. Two-ampere saturated switching is provided with turn on-times of less than 350 nanoseconds.

Circle No. 159 on Subscriber Service Card

Digital Logic Circuits

Semiconductor Div. of Hoffman Electronics Corp. has announced production of two integrated digital logic circuits along with three new unit packages and two new circuit assembly methods that allow more than twice as many circuit functions in a given space than previously available.

The circuits, a dual NAND/NOR gate and a flip-flop, are monolithic silicon integrated microcircuits, constructed by planar epitaxial techniques. Standard packaging is in 10-pin TO-5 headers.

Circle No. 160 on Subscriber Service Card

Single-Chip Circuits

Sylvania Electric Products, Inc., has introduced a series of single-chip integrated circuits featuring switching speeds of 10 nanoseconds.

The 11 models include nine gates and two flip-flops and all operate on a single power supply. Made on a silicon base, the circuits use the monolithic epitaxial technique which, according to Sylvania, provides greater noise protection, higher switching speeds and higher fanout than previous models. The units provide a logic swing of 0.38 to 3.4v with "worst case" noise protection of 800 millivolts at room temperature, or 500 millivolts at an elevated temperature, and a capacitance drive capability up to 600 picofarads. Fanout capability is 7. The circuits are 0.050 in. square and 0.006 in. thick and contain the equivalent of 28 active and passive components on each chip.

Circle No. 161 on Subscriber Service Card

Ranging Picoammeter

A picoammeter capable of ranging automatically from ±1 picoampere to ±1 ampere has been announced by Edgerton, Germeshausen & Grier, Inc.

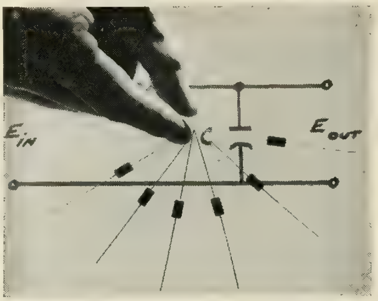
The Model ME-8 is solid state and uses semiconductor circuitry instead of the usual electrometer tubes. Manufacturers claim the device can recover from large input overloads in less than 30 seconds with no drift, offset or other damage. Ten seconds recovery time is said to be typical.

Fullscale range in both automatic and manual modes is from ±1 x 10^{-12} amperes to ±1 ampere. The instrument provides 0 to 10v and 0 to 1v (precision) analog signals.

Circle No. 162 on Subscriber Service Card

Fixed Glass Capacitors

Westinghouse Electric Corp.'s capacitor department is introducing a line of fixed glass capacitors, suited for close tolerance instrumentation applications.



The four styles now available—CYW10, 15, 20 and 30—have capacitance values up to 10,000 picofarads at voltages to 500v dc. They meet or exceed MIL-C-11272B requirements. The units have a dissipation factor of less than 0.1% with an insulation resistance greater than 100,000 megohms. Temperature coefficient of capacitance is 140 ±25 parts per million per degree C. Unit-to-unit variation in temperature coefficient is less than 10 parts per million. Drift factor is less than 0.1%.

Circle No. 163 on Subscriber Service Card

Phase Shift Circulator

An L-band differential phase shift circulator capable of handling 6.5 mw peak power and 10 mw average power has been introduced by Raytheon Co.'s Microwave Devices Operation.

The CLH-3 operates in the 1,280 to 1,350-mc band and can be used as a duplexer or an isolator by connecting suitable loads. Isolation is greater than 20 db; insertion loss is less than 0.9 db over the operating band.

Circle No. 164 on Subscriber Service Card

Resolver-Synchro Simulator

North Atlantic Industries, Inc., is marketing the Series 530 resolver synchro simulator which generates the electrical data of angular shaft position of both three-wire synchros and four-wire resolvers to 2 seconds of accuracy at all angles.

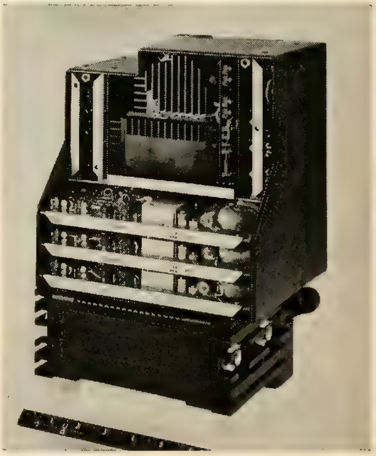
The unit uses a 360-degree readout based on a seven-digit in-line display which provides 0.0001 degree resolution. Operating frequency is 400 to 1,000 cps. Input is 26 and 115v. Outline line to 11.8, 26, 90 and 115v are switch-selected with either input.

Circle No. 165 on Subscriber Service Card

Rate Gyro System

Norden Div. of United Aircraft Corp. has developed a three-axis rate gyro system with the capability of making precise measurements of angular rates about three mutually perpendicular axes.

The heart of the system is three RI



203 floated rate integrating, inertial quality gyros. The unit is a modularized assembly consisting of three servo amplifiers, two 20-v dc regulators, a 10,000-cycle power supply, a gyro motor power supply and a base casting containing the three rate integrating gyroscopes.

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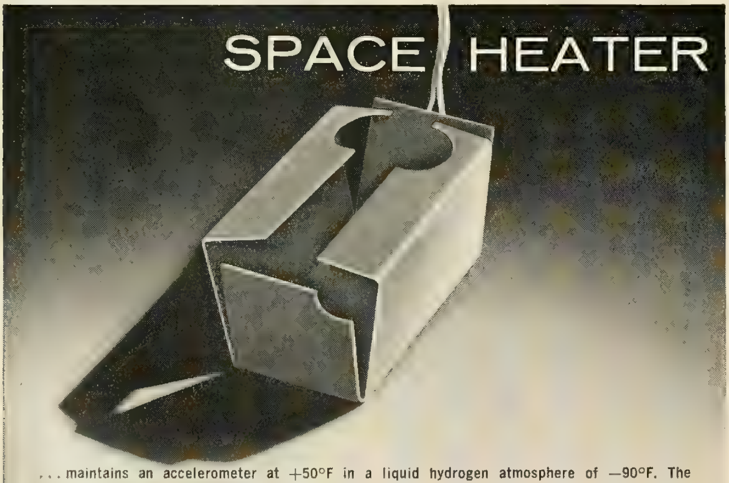

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Readout Memory Device

Burroughs Corp.'s electronic components division has available a readout memory device that has eliminated the need for flip-flops and replaced them with a silicon-controlled switch.

In the unit, each SCS replaces two transistors, four resistors and several diodes and capacitors per memory element. The switch permits a 60% reduction in size of the device.

Two basic types incorporate up to 16 bits of memory per module. The units accept information in forms ranging from dc levels to 100-microsecond pulses. Standard modules use 12-v logic levels and trigger inputs. Character sizes range from standard 0.6-in to 2½-in types.

Circle No. 167 on Subscriber Service Card

Traveling-Wave Tube

A 20-watt continuous wave, traveling-wave tube, 9½ in. long and 1 in. in diameter, has been introduced by Microwave Devices Div. of Sylvania Electric Products, Inc.

The SYT-4353 is designed to operate over a 5 to 11-kc frequency band. Typical operating parameters include a beam voltage of 3,200v; beam current of 75 milliamperes, and a 40-db gain. Environmental parameters include 20 g's vibration, 50 g's shock, 70,000 ft. altitude and operating ambient temperature of —54° to 95°C.

Circle No. 168 on Subscriber Service Card

Integrated Logic Circuit

General Instrument Corp.'s Semiconductor Products Group has available a monolithic NAND/gate integrated logic circuit in which all elements are built on the same silicon substrate.

The NC-301 operates from a single supply voltage set in the 3 to 6v range. It may be used up to a clock frequency of 5 mc. Typical operating characteristics include: fan in, four NAND gates; ambient temperature, 25°C; fan out, 10 NAND gates; propagation time, 12 nanoseconds; power drain, 1.5 mw at 50% duty cycle; and noise margin, 0.5v.

Circle No. 169 on Subscriber Service Card

Resistivity Tester

A resistivity test set that does not require electrical contact with the material under test has been developed by Standard Telephones and Cables, Ltd., an affiliate of ITT Corp.

The Model 74711 operates on the principle of measuring the damping effect of the sample on a lightly loaded tuned circuit. The transistorized test set is useful for the rapid testing of thin slices of semiconductor material. It also measures thicknesses of thin sheets of semiconductor material and detects changes in resistivity around discontinuities in large-area samples.

Measurement range is 10^{-2} to 10^{-6} ohm centimeters.

Circle No. 170 on Subscriber Service Card

Resistor Test Kit

Corning Glass Works' electronic products division has available a resistor test network kit, featuring two evaluation microcircuits, each containing a dozen thin-film tin oxide resistors.

Each microcircuit is on a wafer measuring 7/16 x 11/16 in. Substrate material is alumina, glazed with a special aluminosilicate glass. The resistors have values of 0.5, 5 and 50 K ohms. The kit also includes a schematic diagram of the test circuit, a photograph of the circuit before coating and lead attachment and technical information.

Circle No. 171 on Subscriber Service Card

500-MW Laser

A 500-Mw pulse laser requiring no amplifier is being marketed by Korad Corp., a subsidiary of Union Carbide Corp.

The ruby laser has a rise time of 3 to 6 nanosec. and is accurate to within 1 ft. at ranges of 300 mi. or more. Typical energy output is 4 joules, but can be converted to a conventional laser oscillator with a typical 0.5-ms output of at least 50 joules. The device operates at room temperature and can be cooled with tap water. Beamwidth is nominally 7 milliradians. Repetiton rate is 1 per minute.

Circle No. 172 on Subscriber Service Card

Phase Standard/Meter

Acton Laboratories, Inc., is marketing an ultrasonic primary phase standard/meter that measures phase shift to ±0.1° absolute by comparing its precision internal reference with a single return from a component under test.

The Model 718-B generates two voltages having an adjustable phase relationship. Shift is read in a continuous range of 0 to 360 degrees on two calibrated dials. The instrument is self-calibrating and may be specified for use at any frequency from 20 to 300 kc. Output is 1 to 6v RMS into load impedance of 5 k ohms minimum.

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special report

electro-optical systems

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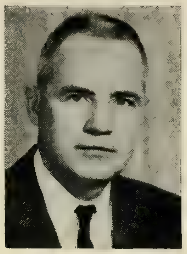
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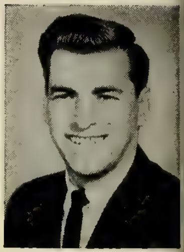
ATKINSON

Edmond S. Klotz: Named vice president-engineering at Micro-Radionics, Inc., Van Nuys, Calif.

Kenneth B. Kelly: Appointed switching systems product marketing manager at the eastern operation of Sylvania Electronic Systems Div. of Sylvania Electric Products, Inc., Needham, Mass.

Philip R. Gustlin: Appointed general manager for Electronic Specialty Co., Electronics Div., Portland, Ore.

E. Donald Gittens: Elected executive vice president of American Bosch Arma Corp., Garden City, N.Y.

Baxter H. Armstrong: Named a senior member of Lockheed Missiles & Space Co. Research and Development Div.'s physical sciences laboratory, Sunnyvale, Calif.

Murray Allewitz: Appointed a vice president of Green Hydraulics, Inc., Los Angeles.

Dr. Robert J. Prochaska: Appointed manager-polycarbonate research and development at the Chemical Materials Dept. of General Electric Co., Pittsfield, Mass.

Paul Mehren: Elected vice president-finance at Western Gear Corp., Lynwood, Calif.

Robert C. Atkinson: Appointed a district sales engineer—components, Motorola Semiconductor Products, Inc., covering Boston, New Hampshire, and Maine.

George R. Costello: Named assistant head, Guidance and Technology Dept., Sensing and Information Subdivision, for Aerospace Corp.'s San Bernardino, Calif., operations. **Charles F. Dedo** named head of the Realiability Information Section, Systems Analysis Subdivision.

J. E. Niebuhr: Appointed general manager of Datapulse, Inc.'s Datapulse and Nesco Instruments Divs., Inglewood, Calif.

Warren L. Yager: Named director of foreign operations for Hexcel Products, Inc., Berkeley, Calif.

Roy Keir: Appointed senior consulting engineer for Digital Science Consultants, Van Nuys, Calif.

Dr. Joseph Kempner: Named head of the Applied Mechanics Div. of the Polytechnic Institute of Brooklyn, N. Y.

George Wulfing: Elected president and director of Digital Electronics Corp., Westbury, N. Y.

Keith G. Huntley: Elected vice president-engineering of Farrington Electronics, Inc. and Farrington Business Machines Corp., New York City.

Clarence H. Hutchinson: Appointed financial director of Hexcel Products, Inc., Berkeley, Calif.

Charles E. Hunter: Appointed general manager of Thiokol Chemical Corp.'s Wasatch Div., Brigham City, Utah.

Robert P. Benjamin: Named director of development engineering at Defense Electronics, Inc., Sherman Oaks, Calif.

James M. Wallace: Elected vice president of Westinghouse Electric Corp.'s East Pittsburgh divisions.

C. A. Zimmerman: Named manager of propulsion engineering in Lockheed Missiles and Space Co.'s research and development division, Sunnyvale, Calif.

Darle W. Dudley: Appointed manager of the mechanical transmission section of Mechanical Technology Inc., Latham, N.Y.

Leonard L. Broderick: Appointed project coordinator for engine-material handling products at Allis-Chalmers' Defense Products Div., Milwaukee.

Gustav Stadler: Elected president and general manager of the C. E. Johansson Gage Co., Dearborn, Mich.

Howard A. Acheson, Jr.: Appointed vice president of Acheson Industries, Inc., and manager of its international group of Colloids Cos., Port Huron, Mich.

James E. Sloan: Appointed manager-data communications programs for Radio Corp. of America's Communications Systems Div., New York City.

Franklin B. Lincoln, Jr.: Promoted to the corporate staff of Litton Industries, Beverly Hills, as vice president and special counsel.

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48th Annual Meeting, Federation of American Societies for Experimental Biology, Conrad Hilton Hotel, Chicago, April 12-18.

IEEE Symposium on Microelectronics, Chase-Park Plaza Hotel, St. Louis, April 13-15.

Institute of Environmental Sciences, Annual Technical Meeting and Equipment Exposition, Sheraton Hotel, Philadelphia, April 13-15.

American Power Conference, sponsored by IEEE and Illinois Institute of Technology, Sherman Hotel, Chicago, April 14-16.

IEEE and ASME International Conference and Exhibit on Aerospace Electro-Technology, Westward-Ho Hotel, Phoenix, Ariz., April 19-25.

ASTME Annual Meeting, Convention and Exposition, Detroit, April 19-25.

Seminar on Nonlinear Partial Differential Equations in Mathematical Physics, sponsored by Air Force Office of Scientific Research, Army Research Office, and American Mathematical Society, Hotel New Yorker, New York City, April 20-23.

First Canaveral Space Congress, sponsored by Canaveral Council of Technical Societies, Ramada Inn, Cocoa Beach, Fla., April 20-22.

Spring Joint Computer Conference, American Federation of Information Processing Societies, Sheraton Park Hotel, Washington, D.C., April 21-23.

IEEE Southwestern Conference and Electronics Show, Dallas Memorial Auditorium, Dallas, April 22-24.

Society of American Value Engineers Annual Meeting, Ambassador Hotel, Los Angeles, April 23-24.

The Combustion Institute, Western States Section, Spring Meeting, San Jose, Calif., April 27-28.

IEEE and ISA Region 6 Annual Conference, Salt Lake City, Utah, April 29-May 1.

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M/R

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- deficiencies
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published june 1, 1964

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The Revolution: Part III

CURRENT SHIFTS in Pentagon policy and organization will have a revolutionary impact on the missile/space industry, as we have noted in the two previous editorials. In the third and final part of this appraisal, we should like to take a close look at what these changes will mean to the industry, particularly in terms of its marketing requirements.

With the three services now acknowledging the inevitability of the new approach to military research and development and procurement, where should a company direct its intelligence and sales effort? At the Dept. of Defense level or to the individual services?

Before attempting to answer this question, we should emphasize that what might be called capitulation to the McNamara reorganization has not been uniform among the three services or even within any single service.

The Army, which has benefited the most from the new approach, has had relatively easy sledding thus far in the McNamara regime. This will change. Although the Army can hope to benefit from the new tactical emphasis, it will find more competition in this area from the Air Force and Navy.

The Air Force has fought the hardest against the McNamara overhaul of the defense establishment. Since the first impact of the McNamara philosophy was on such Air Force programs as *Skybolt,* the B-70, the B-58 and *Dyna-Soar,* it must have seemed to the junior service that the new Secretary was on a one-service vendetta. The result was a vigorous, and unsuccessful, battle. The Air Force now has decided there is more to be gained from cooperation than from obstinacy. It is assigning some of its best officers to slots in the Directorate of Defense Research and Engineering. It is embarked on a conscious effort to work closely with DDR&E in those areas—such as operations—where it believes that office most needs service advice and experience. It is passing the word to lower echelons—and the word is cooperate.

The Navy is the last holdout. Currently, it is going through the same soul-searching already experienced by the Air Force. The transition has begun and the concession to the inevitable will follow.

The result of all this is a new era of cooperation in the Pentagon.

The question therefore arises of whether industry firms now should direct their marketing efforts toward DDR&E rather than the individual services. The answer is a qualified no. Obviously, it makes good sense to keep DDR&E well-briefed, in order to assure a more knowledgeable atmosphere for program decisions reaching that level. But the great majority of procurement actions still are initiated at the service level. It is a rare exception when DDR&E pushes against service opposition. The answer, then, is to inform and sell both DDR&E and the services.

As the tactical area grows in importance, this will be even more true. Industry firms, selling smaller items, will find themselves dealing at lower levels. Their future will depend not upon selling strategic systems to generals but upon selling small items to lieutenant colonels.

Companies must prepare for a more diversified and continuous sales program. Profits will depend not upon the sale of one large system every four years but on continuing smaller sales. This will require a larger sales force and an increased use of such sales aids as advertising and publicity.

Many missile/space firms will find themselves dealing with an unfamiliar environment. The industry well understands the operational environment of the ballistic missile, because it creates that environment—the silo. But this industry is far less familiar with the tactical environments in which the Army, Navy and Air Force operate. This brings a need for more field study and such steps as assignment of representatives to service technical schools.

An increase in smaller, less sophisticated programs will mean a return to long-production-run items, where the stress is on low cost rather than extra high quality. Reliability will be attained by increased simplicity, not by costly and detailed quality control.

The shift to a tactical emphasis also means an eager marketplace for industry ideas. Advanced technology must be applied to simpler problems. The Pentagon is hopeful that industry, possessor of the technology, will provide many of the tactical innovations.

We should emphasize that the strategic market is not dead. There will be studies of new generations of strategic weapons, there will be funding of some of these to the program stage where DOD will retain an option of quick deployment, and there will be improvements of existing weapons.

Activity will continue at a high level in communications and command and control systems.

But the tactical area is the growth area. And the industry will have to adapt itself to what is an unfamiliar selling place for many missile/space firms.

CONTINUED GROWTH in the defense budget can be expected. It probably will be a more moderate growth than in the past, but the budget most certainly will not develop the sharp downturn predicted by some analysts.

Talk of conversion of this industry to civilian production is unsound. Firms in the industry will continue to diversify their product mix to both civilian and government fields, as in the past, but the knowledge and experience of this industry will continue to be directed to those areas where it most benefits the Nation—the fields of space and defense.

Civilian space spending probably will continue at its present level for some years. As funding of the manned program peaks out, the National Aeronautics and Space Administration will initiate, in a favorable Congressional atmosphere, the unmanned programs which have been delayed.

Thus, firms in the missile/space industry face a promising future, a period of new opportunity. But, like all revolutions, this one will have its winners and its losers. Those who adjust will survive. The time to prepare is now.

William J. Coughlin

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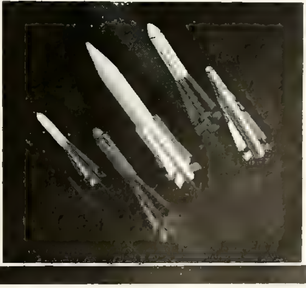

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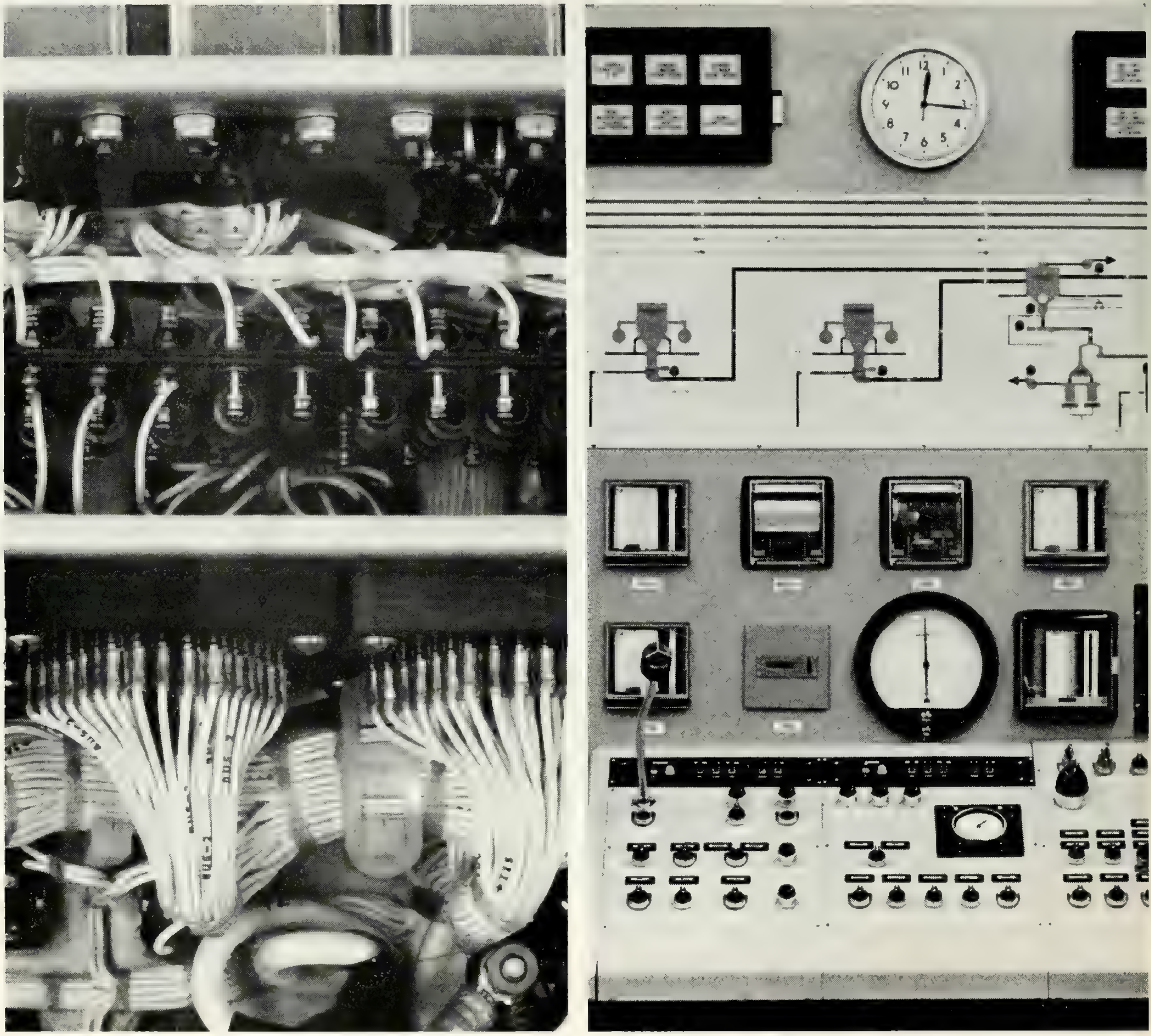

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APRIL 20, 1964

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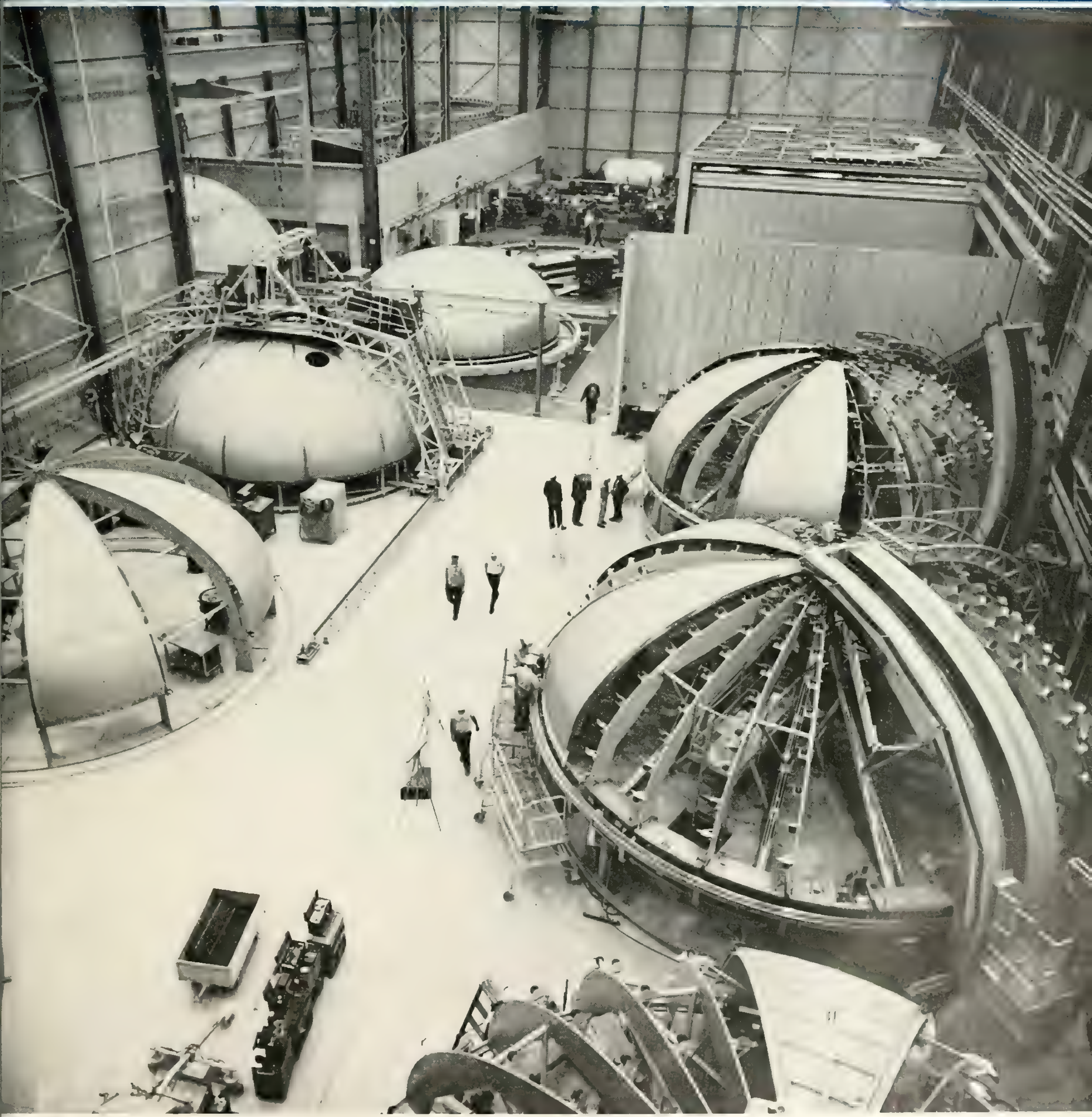
HE WEEKLY OF SPACE SYSTEMS ENGINEERING



Saturn V S-II Stage Bulkheads at North American

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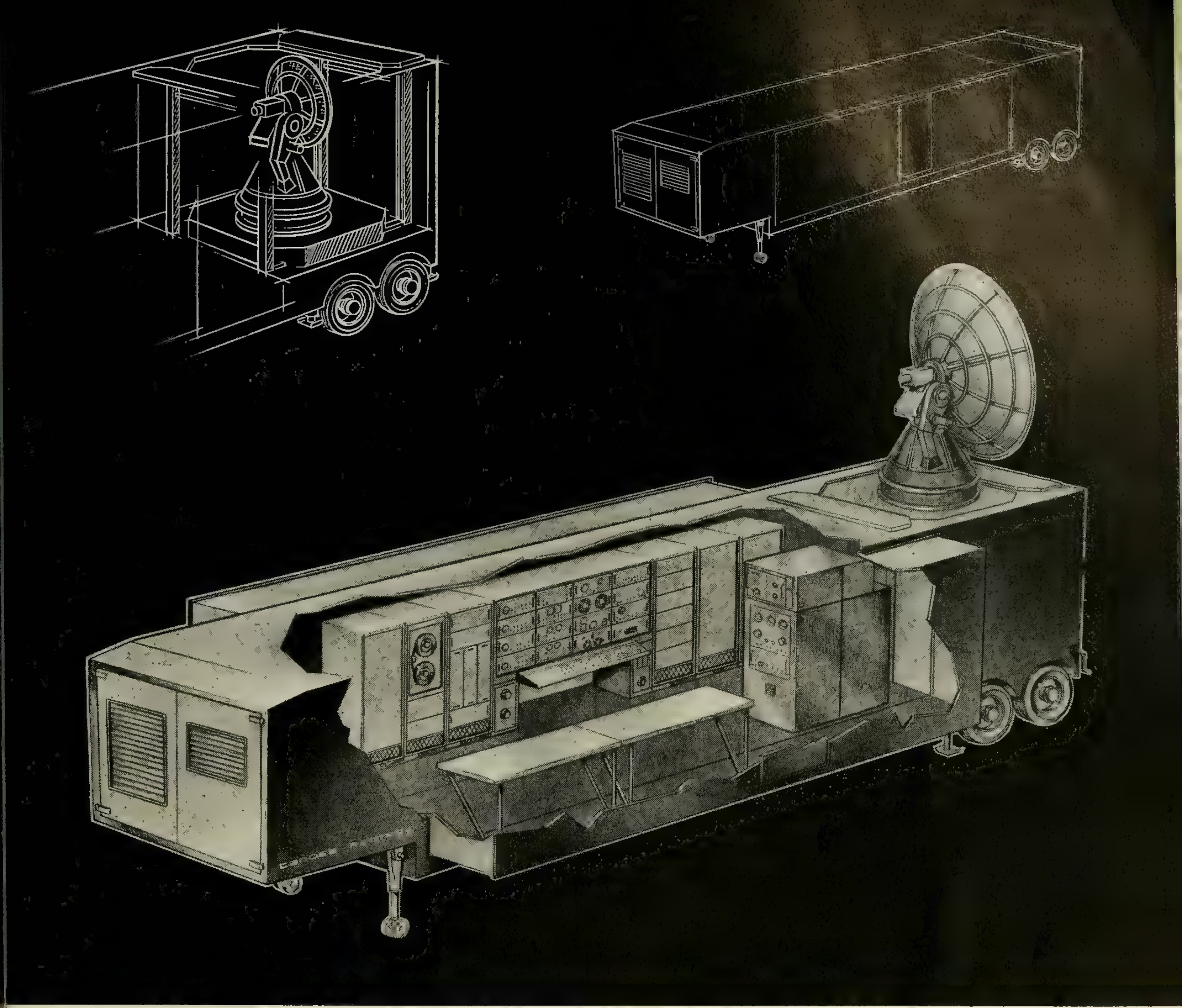

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missiles and rockets

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April 20, 1964

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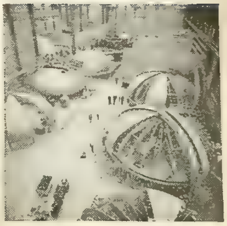

Saturn V second stage (S-II) propellant bulkheads are shown being fabricated at North American's Space Div., Downey, Calif. Bulkheads separate, insulate and contain the launch vehicle's propellants. The S-II stage of the Apollo spacecraft's booster is being developed by NAA for NASA's Marshall Space Flight Center.

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47,559 copies this issue

Polaris Guidance (cont.)

To the Editor:

I am indeed grateful to Associate Director (of MIT's Instrumentation Laboratory) Forter for his prompt confirmation of the limited insight into system engineering displayed by the Laboratory in the *Polaris* guidance development (Letters, April 6, p. 7).

To clarify the record:

1. The *Polaris* Guidance Shipping Container is the direct product of the inordinate temperature requirements of the MIT guidance unit design. A multi-agency improvement program has subsequently succeeded in eliminating the batteries and enlisted attendant by adapting thermal technology originally developed to support the artificial insemination of cattle. The redesigned transit case weights 2,000 lbs.
2. The guidance system referred to in my letter (March 16, p. 5) is at least the third generation of MIT design effort. It follows both the SPIRE/SPIRE JR. and THOR developments.

It appears that the academic environment is at least conducive to gamesmanship if not to system engineering. For the benefit of Messrs. Forter and Eliason (also Letters, April 6, p. 7), system engineering also includes treatment of the logistic consequences of their academic peregrinations.

Frederick J. Howard
Freeport, N. Y.

Soft on Soviet Space?

To the Editor:

Regarding the recent editorial on the *Ranger* failures, the impression I get is that you are under some form of obligation to the Caidin-Lear School. How they must have changed you!

My reasons: 1) After initiating a valuable line of much-needed criticism of Titov in May, 1962, you published a letter from Caidin and immediately reverted to what, for want of a better term, I call your "pro-Russian" attitude. 2) Following Caidin's letter of December, 1963, criticizing, violently but not without reason, your views on *Saturn,* you referred to it, almost gleefully I thought, as an "orbiting junkpile."

Having read his books I think I understand Caidin's non-critical attitude to the Russians, but I fail to understand yours.

J. E. W. Surman
London, England

P.S. I like your magazine. It is most entertaining and generally factually accurate.

We are not aware of being especially critical or uncritical of the Soviet space program. Perhaps we seem more critical of the U.S. program because that is our principal interest.—Ed.

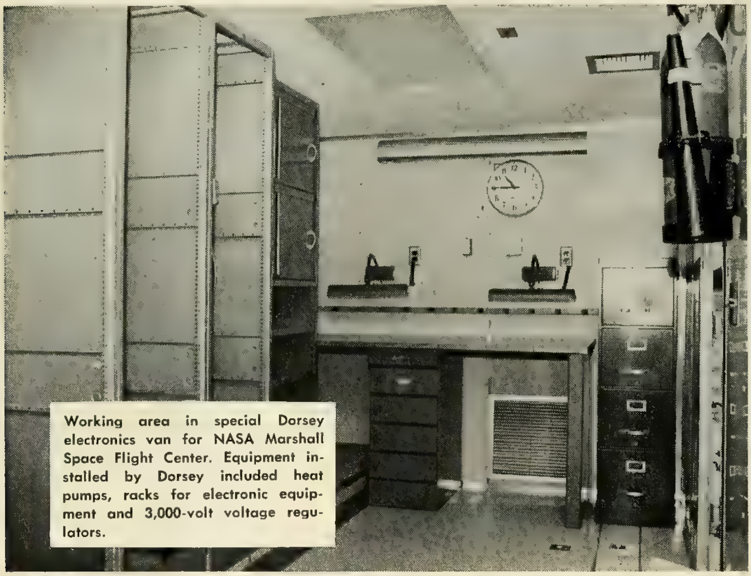
Mad About McNamara

To the Editor:

In your recent editorial pap praising Robert S. McNamara, you neglected to mention one of his administrative duties. He is the chief spokesman on the Viet Nam farce. Although McNamara may be a whiz kid at managing money for defense systems for imaginary aggressors, one can seriously doubt his and the Administration's apprehensions over providing a policy in Viet Nam. There are 15,000 Americans in Viet Nam. Those in the war are shooting and are being shot at. Tactical air support is inadequate, using only T-28's. (Defunct B-26's withdrawn.)

Our policy has nothing to do with military strategy, being one of defensive response only. This position is untenable, and we will most likely withdraw or compromise à la De Gaulle. If the domino theory is correct, it will be disastrous for 240 million people. Yes indeed, a well-managed Defense Department.

Robert S. Smith
W. Lafayette, Ind.



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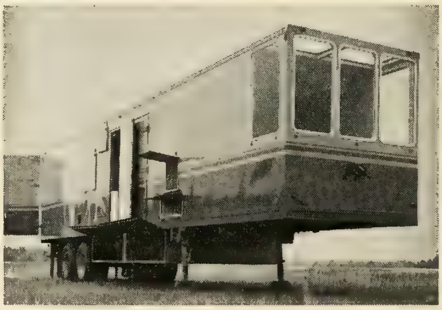

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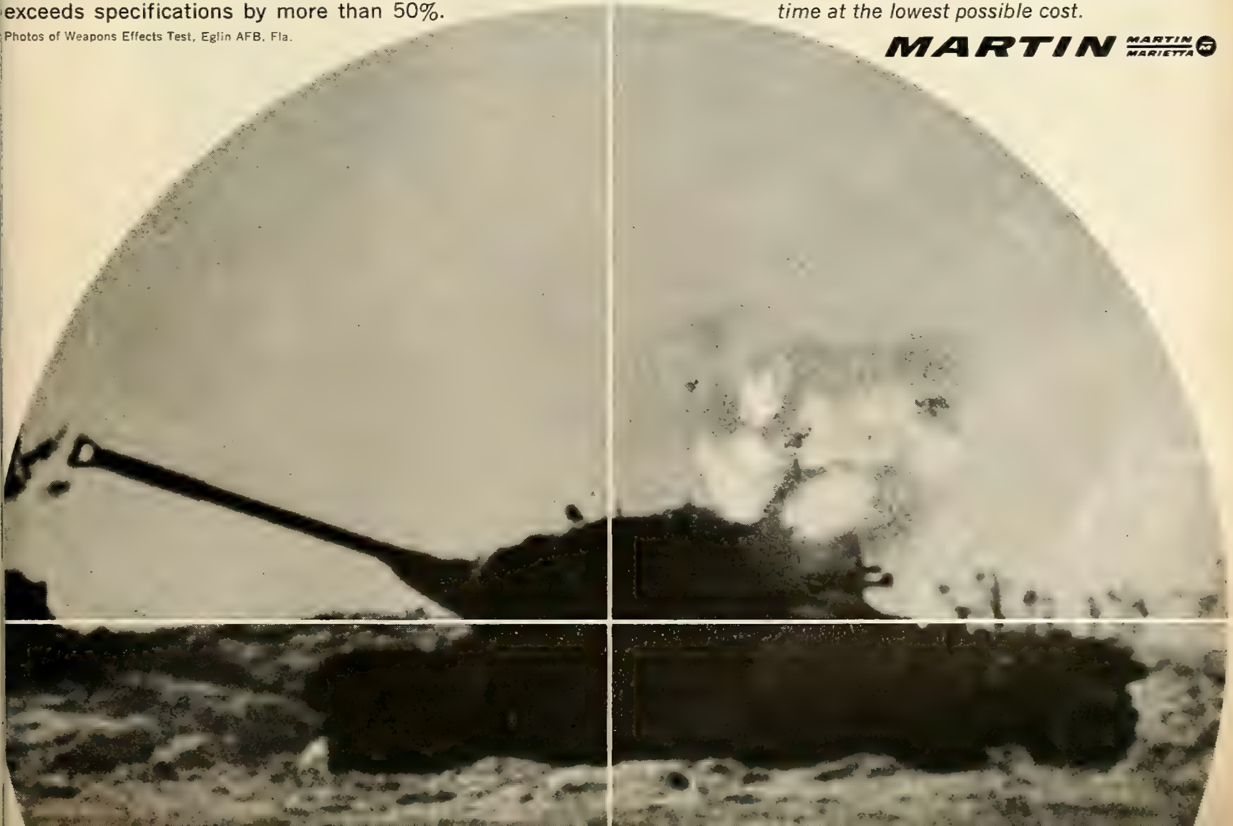

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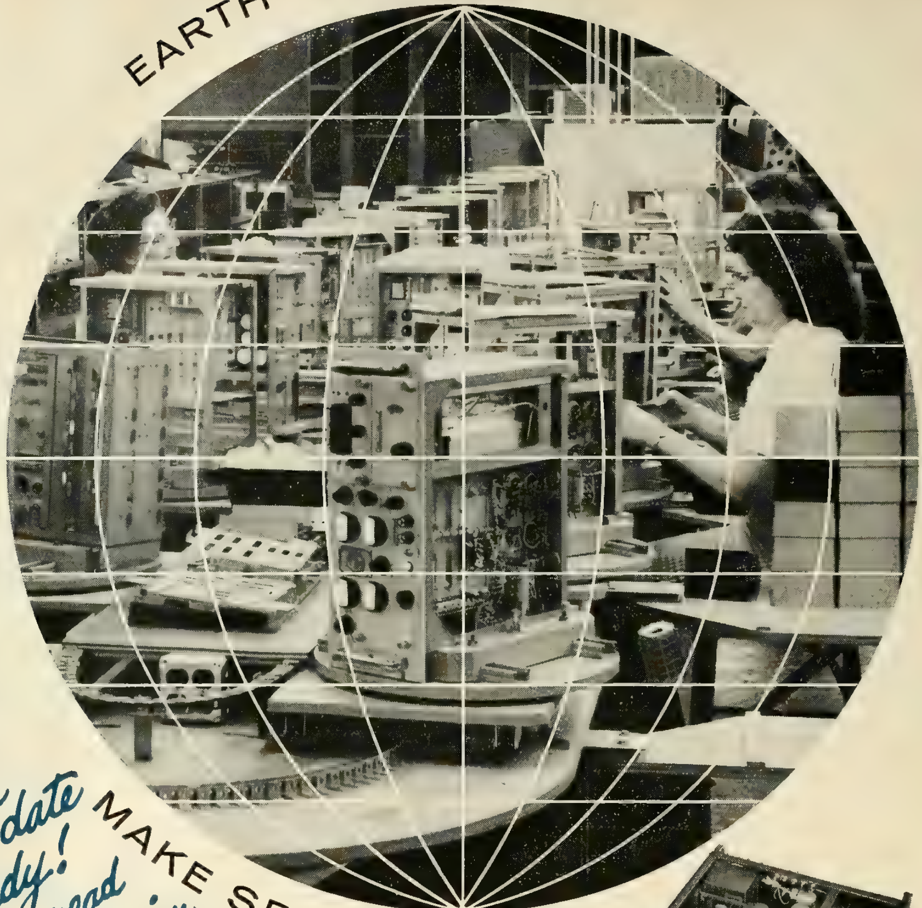

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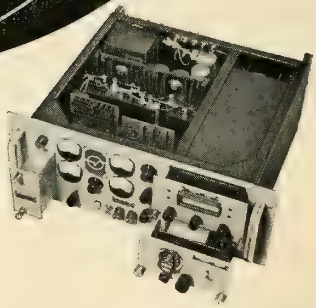

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The Countdown

WASHINGTON

Centaur Slip Slows Surveyor

With the launch of *Centaur 3* now slipping into May at the earliest, NASA will now have to launch one of the liquid hydrogen upper stages every two months for the rest of this year if it is to stay on schedule. This appears to be impossible; if so, the major result will be further slippage in the *Surveyor* lunar soft-landing program, since *Centaur* is its launch vehicle.

Diminishing Returns from Probes Feared

The Senate Space Committee is taking a hard look at the phasing of NASA's entire unmanned probe program. Members are concerned that slippage in some of the projects may crowd too many shots into the 1966-68 period, when the data they supply may have lost its usefulness.

British Missile Studied for Mauler Role

Difficulties encountered in the *Mauler* program, and uncertainty within the Army as to whether they can be corrected, have caused officials of that service to begin casting around for an interim replacement. One possibility is Britain's *Thunderbird,* a surface-to-air missile with a capability between the *Redeye* and the *Mauler*. If the Army should decide on *Thunderbird,* it hopes to arrange some sort of barter agreement to avoid adding to the U.S. balance-of-payments deficit.

SNAP Flight Funds Pressed at Capitol

The Joint (Congressional) Committee on Atomic Energy has voted funds for flight-testing of *SNAP-10A* despite the fact that they were not requested by the Administration (COUNTDOWN, April 13). Funds for the *Rover* and Pluto programs also are faring well in the authorization bill, which is expected to be reported this week.

Voyager Debut Likely in '69

Earliest target date for a *Voyager* flight now appears to be 1969. The space agency recently told Congress that it plans to select a conceptual design utilizing early information gained during this year's *Mariner* flight to define a mission for more detailed exploration of Mars in that year. Current funding allocations indicate that 1968 will be the earliest date for further missions to Venus.

Syncom Tested with Sixth Fleet

It has been disclosed that the USNS Kingsport left its station at Lagos, Nigeria, last year and joined the Sixth Fleet in the Mediterranean, where it relayed non-operational communications to Lakehurst, N.J., via *Syncom II*. The results were reported to be highly successful.

Pacific Underwater Range To Be Built

Navy officials are in the process of acquiring land for a Pacific Underwater Tactical Range—off the coast of the island of Lanai northwest of Hawaii. The range will be used for test and evaluation of submarine sonars, fire control systems and underwater weapons—both torpedoes and *Subroc* missiles. The Fiscal Year 1965 budget request provides $4.1 million for its establishment.

PACCS To Be Improved This Year

Delivery of new KC-135B aircraft to the Air Force this year will add a new dimension to the Post-Attack and Control System (PACCS) Supplied with the latest communications and electronic equipment, the planes are expected to increase endurance, reliability and overall effectiveness of the system. Studies are also under way to provide SAC aircraft with the ability to control missiles from an airborne command post—making PACCS the strategic control segment of the Post-Attack National Military Command System.

INDUSTRY

Gemini Advances at McDonnell

Gemini astronauts Virgil Grissom and John W. Young have checked into McDonnell Aircraft Corp. for an extended stay which will include heavy use of the company's new *Gemini* missions simulator. The *Gemini-Agena D* docking simulator, also unveiled by the firm recently, is now being disassembled for shipment to the Manned Spacecraft Center in a few weeks. McDonnell reportedly has assigned individual in-plant project managers for *Gemini* capsules 2 and 3, as further insurance of meeting their delivery dates in the second and third quarters of this year respectively.

Wasp's Sting Appraised at Aberdeen

A report is expected next month on results of a recently completed round of tests of the 40-mm *Wasp* rocket at the Army's Aberdeen (Md.) Proving Grounds. Emerson Electric Co. in St. Louis, *Wasp* contractor, completed prototype development in February. The weapon is a 1-lb., 7-in.-long, two-stage device which is spin-stabilized and uses a zero-length launcher. Designed primarily as an air-to-ground system fired mainly from helicopters, it also can be used as a ground-to-ground weapon.

STL Wins Added OGO Production

NASA is negotiating with TRW Space Technology Laboratories to purchase two more *Orbiting Geophysical Observatory* (*OGO*) spacecraft at a cost of $17 million. *OGO D* —the first of the two—will be launched in 1965, carrying some 20 scientific experiments into a 600-mi. polar orbit. *OGO E,* expected to be launched in 1966, will take about the same number of experiments into a highly elliptical orbit with an apogee of 90,000 mi.

INTERNATIONAL

French Replacing Sahara Range

France and Portugal have signed an agreement calling for construction of a French tracking station in the Azores Islands. Working in connection with the Biscarosse base in southwest France, the station will provide a 1,400-mi. range for development of France's *Polaris*-type missiles. This will take the place of the Hammaguir range in the Sahara, which the French must vacate in 1967.

NOTS Testing French Matra Missile

Naval Ordnance Test Station is evaluating the French air-to-air *Matra* missile, assisted by French Navy personnel assigned to the test program. Already operational on French fighter/attack aircraft, the 10-ft.-long solid-propellant missile has both a semiactive radar-homing and an infrared guidance capability.

The Missile/Space Week

Webb Reveals JPL Terms

NASA Administrator James E. Webb revealed that for the first time the Jet Propulsion Laboratory will be forced to carry out directives from the space agency.

Webb told a news conference that a provision requiring such action is in the new contract that the space agency is negotiating with JPL. The current contract, which terminates this year, had no such provision.

Webb also said that the new contract will pay a fee to California Institute of Technology, of which the laboratory is part, that will be based on performance. He also said that the JPL management structure will be changed to bring it more in line with that at NASA field centers.

This apparently means that a deputy director will be appointed to handle JPL industrial relations with contractors.

Webb said that NASA has no plans to make JPL a field center, but he also indicated that there are no plans for the space agency to divorce itself from the laboratory despite the six straight failures in the *Ranger* program.

Committee Probes Delta Fire

A 14-man "fact-finding committee" is probing the cause of the accidental ignition of a *Delta* third stage April 14 at Cape Kennedy. Eleven men were burned, three of them critically, in the incident. Two of the three critically injured were reported near death late last week.

No cause for the accident was given during an April 15 briefing at the Cape conducted by Robert Gray, chief of NASA's Goddard Space Flight Center's launch operations at Cape Kennedy.

The injured were employed by Douglas Aircraft Co., *Delta* prime contractor; Ball Bros. Research Corp., which makes the *Orbiting Solar Observatory* scheduled to be launched by the *Delta*, and by NASA.

The system, according to NASA officials, was at F minus three days when the accident occurred. Workmen were preparing to move the *OSO* and mated third stage of *Delta* to a balance table when the *Delta* stage ignited. The booster and payload were scheduled to go to the launch pad April 15, and launch was set for April 21.

Further injuries were averted because 11 other members of the "highly experienced" team were outside the assembly and checkout building when the accident took place.

Although the *Delta's* third stage igniter was inserted at the time of the accident, dual squibs that activate the stage were disconnected and grounded as a precaution against accidental ignition.

The fact-finding committee is headed by Daniel G. Mazur, Goddard Space Flight Center.

Project Fire Shot Satisfactory

Space agency officials report good data from a preliminary look at the results of the successful first launch of the Project *Fire* re-entry vehicle.

Telemetry reported that Project *Fire*, launched from Cape Kennedy April 14 on a ballistic trajectory, survived re-entry and splashed down in the Atlantic Ocean.

Flight performance was only slightly off the planned "nominal" for the mission.

Re-entry speed reached 37,745 fps (25,750 mph), not more than 50 fps higher than expected. Re-entry heating reached 11,200°K, instead of the planned 11,300°K. The lower heat apparently stemmed from the lower re-entry angle of 14.5 degrees negative, compared to the planned nominal of 15 degrees.

The vehicle was sighted by observers on Ascension Island who described it as resembling a fireball, but not as bright as they had expected. It impacted 200 miles south of Ascension after a 32-min. flight.

Richard Dingeltein, chief of the mission's technical staff at Langley AFB, Va., said all data will be given to *Apollo* program personnel as soon as it is reduced. They expected a quick check of data to be completed last week and complete reduction within a month.

Dingeltein said no date has been set for the next launch, but *Fire II* will not be launched if *Fire I* provides all the necessary data.

Shots of the Week

The Soviet Union on April 12 launched the second in its *Polyot* series of maneuverable satellites. *Polyot 1* was launched last Nov. 1. A Tass news agency release said that *Polyot 2* was aimed at perfecting space rendezvous techniques. An electronic brain installed on the satellite enabled it to "substantially change the angle of inclination of its orbital plane," according to Tass.

- On April 9, a day after a modified version boosted the first unmanned *Gemini* capsule into orbit, the Air Force successfully fired a *Titan II* ICBM from Cape Kennedy. The missile carried an instrumented warhead to a target in the South Atlantic.
- The first Project *Fire* re-entry vehicle was launched from Cape Kennedy April 13 aboard an *Atlas* booster (see story this page).
- The Air Force launched a *Minuteman* ICBM from Vandenberg AFB, Calif., on April 13. Shot was launched from a silo and was aimed at a target 5,000 mi. down the Pacific Missile Range.

FCC Gives ComSat Go-Ahead

The Federal Communications Commission has approved a Communications Satellite Corp. application (M/R, Mar. 9, p. 9; Mar. 23, p. 8) to build two synchronous communications satellites. Launch is planned for early 1965.

The experimental/operational system is to be used initially between the U.S., Canada and Western Europe to determine its suitability for voice and telecommunications transmission.

Hughes Aircraft Co. received a contract to build the system last month along the lines of its *Syncom II* satellite. Finalization of the award has been awaiting expiration of the FCC statutory filing period.

GT-1 Returns from Orbit

GT-1, the first unmanned *Gemini* capsule launched April 8 by NASA (M/R, April 13, p. 12), re-entered Earth's atmosphere April 12 at 4:00 p.m. EST after 69 orbits.

The capsule re-entered over the South Atlantic. No recovery effort had been planned.

Grissom, Young To Fly Gemini

Air Force Maj. Virgil I. Grissom and Navy Cmdr. John W. Young will comprise the crew of the first manned *Gemini* when it is launched late this year or early in 1965.

Named by NASA as backup crew were Cmdr. Walter M. Shirra and Air Force Maj. Thomas P. Stafford.

An ear ailment similar to the one suffered by Col. John Glenn removed Lt. Cmdr. Alan B. Shepard, like Grissom and Shirra, a *Mercury* veteran, from consideration as a crew member on the first *Gemini* flight.

JPL Tells Mars Plan

JPL would like to use a steerable entry vehicle or a steerable parachute system for its 1969 Mars shot. Having almost given up hope of anything but a flyby of the planet in 1966, JPL is anxious to land the complete 1969 vehicle and achieve telemetry from the surface of the planet.

To get the most value from such a probe, it must land near an area that might be expected to support life. Area of chief interest in this respect for JPL is Syrtis Major—a prominent green area on the planet's equator. Two mid-course maneuvers are planned, the aim being to achieve an entry angle into the tenuous Martian atmosphere of between 20 and 90 degrees.

Trajectory calculations subsequent to the maneuvers will indicate the expected angle of entry and enable a correction angle for an in-atmosphere maneuver to be computed. This would then be programmed into the spacecraft system.

Whatever aerodynamic surfaces were used would in fact provide a third maneuver without the weight penalty of an additional rocket system. Although JPL expects to gain experience of remote television-monitored directional control of spacecraft with the *Surveyor* program, use of this technique for the Mars probe is unlikely owing to the transmission time-delays between Earth and Mars.

Explorer IX Succumbs

The *Explorer IX* satellite re-entered the atmosphere and burned up April 9 after more than three years in space.

Explorer IX was NASA's most effective satellite for measuring atmosphere density and temperature. These measurements were made by noting the effects of atmospheric drag on its orbit.

Explorer IX, launched Feb. 16, 1961, from Wallops Island, Va., traveled more than 340 million miles during its 14,000 orbits of the Earth. It was the first satellite put in orbit by a solid-fuel launch vehicle—the four-stage *Scout*—and the first satellite launched at Wallops.

The lightweight, 12-ft.-dia. balloon paid an extra dividend starting last Dec. 19 when a similar inflated sphere, *Explorer XIX*, was put in orbit to determine sources of atmospheric heating by comparing measurements between the two satellites.

RCA Wins Two Contracts

Marshall Space Flight Center will negotiate with RCA Data Systems Div., Van Nuys, Calif., for purchase of 19 additional ground computer systems to be used in static tests and launch of *Saturn IB* and *Saturn V* vehicles.

The additional systems will complete the required number of 26 RCA 110-A computers for the *Saturn-Apollo* program. Total cost is expected to exceed $47 million.

The RCA 110-A will provide central computer control for *Saturn IB* and *Saturn V* checkout, static tests and launch. They will be used at Marshall, Michoud Operations, Mississippi Test Operations and launch complexes 34, 37 and 39 at Cape Kennedy.

In another RCA contracting development, the firm received a $22 million contract from Grumman Aircraft Engineering Corp., Bethpage, N.Y., for the communications subsystem of the Lunar Excursion Module.

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'Highly sensitive' data . . .

U.S., Soviet Strengths Detailed

Release of LeMay testimony, Goldwater blast followed quickly by DOD denial that U.S. strategic lead has been narrowed

by James Trainor

IN AN UNBLUSHINGLY political move, the Dept. of Defense reacted quickly and surprisingly last week to criticism of U.S. defense policy voiced by Gen. Curtis LeMay, Air Force Chief of Staff, and echoed by Sen. Barry Goldwater (R-Ariz.).

DOD's reaction was surprising in that it contained detailed estimates of the relative strategic strengths of the U.S. and USSR—information that had been considered highly sensitive.

LeMay's criticism was contained in testimony before the House subcommittee on Department of Defense appropriations chaired by Rep. George Mahon (D-Tex.). The February testimony was released April 14. In it, LeMay said that although U.S. forces were "definitely superior" to those of the Russians, he felt that U.S. strength is not "as superior as it was a few years ago. In other words, the gap is narrowing."

A few hours after the general's testimony was made public, DOD had released figures on the relative strengths of the U.S. and Soviet Union with a statement that "questions have been raised . . . regarding the magnitude of our superiority and whether it is continuing to grow. The fact is, it has been increasing and we intend that it shall continue to increase." Classified information was released, the Department said, "so that there may be no misunderstanding of this point."

• **The details**—The points made in the DOD memorandum include:

—The U.S. has about 750 ICBM's on launchers, while the Soviets have "less than one-fourth of that number in operation."

—There are 192 *Polaris* missiles deployed in nuclear submarines, while Russia has "substantially fewer" sub-launched missiles which have only one-third the range of *Polaris* and must be fired from the surface.

—There are 540 strategic bombers on constant alert, while Russia has no more than 120 heavy bombers and 150 medium bombers capable of a two-way mission over the U.S.

—In 1961, the U.S. had fewer than 500 bombers on alert, while the Soviets had essentially the same bomber force they have today.

The DOD analysis did not include the 17 *Regulus* missiles in the fleet nor did it mention the B-47 fleet, which still numbers more than 200. Both systems are to be phased out of the U.S. arsenal. Soviet forces estimated to be able to make only one-way missions over the U.S. were also excluded.

Included were: 129 *Atlas D*, *E* and *F* missiles at 11 bases (27 to be phased out in FY '65); 54 *Titan I* missiles at five bases; 54 *Titan II's* at three sites; and 513 *Minuteman* missiles at three operational bases and a fourth semi-operational site. Twelve *Polaris* submarines account for the 192 missiles, while the 540 strategic bombers are less than the 630 B-52 and 98 B-58 aircraft in the inventory.

• **LeMay's point missed**—While the DOD announcement stressed the numbers of warheads added to the arsenal over the last three years, LeMay was addressing himself to the quality of this arsenal. "So it is a matter of staying ahead," LeMay said in discussing advances in nuclear weapons technology. "It is relative. The gap has narrowed, and I do not think it was necessary to let it narrow, at least to the extent it has, because we dropped off on our testing program.

"If we had had a more aggressive testing program, I think we would still be further ahead of the Russians in atomic weapons than we now are. So it was inevitable that Russia would get into the atomic business, yes, but it was not inevitable that they would close the gap as much as they did."

In other words, while the DOD release addressed itself to numbers of weapons available, LeMay was advocating the development of a high-yield weapon.

Last year, during the Nuclear Test Ban debate, Defense officials admitted that the Russians lead the U.S. in high-yield (100 megaton) weapons. In fact, the largest nuclear device we could build, with a considerable amount of extrapolation, would be 60 megatons. The Russians have tested a 58-megaton weapon that can easily be scaled to 100 megatons; the largest U.S. weapon tested had a 15-megaton yield.

LeMay, in fact, supported the missile programs, although he admitted he would "probably not give as optimistic a picture as the Secretary would. But first let me say I am satisfied with our missile programs, particularly the solid-propellant programs. They are coming along very well."

Two areas of concern to the Air Force chief, however, are the lack of testing under full operational conditions (including detonation of the nuclear warhead) and the vulnerability of ICBM's—including *Polaris*.

• **Goldwater criticism**—In an "issue paper"—one of 21 released by Goldwater for President headquarters April 15—entitled "Defense for the Space Age," the Arizona senator said that he would continue "to raise, until all the facts are in, fundamental questions about the reliability of our intercontinental ballistic missiles. It is not a question of theoretical accuracy. The fact is that not one of our advanced ICBM's has ever been subjected to a full test under simulated battle conditions."

Technically, Goldwater is correct, since the *Polaris A-1* test conducted in the Pacific in 1962 with a live nuclear warhead was a heavily instrumented missile rather than an operational weapon. Tests have been conducted from the Atlantic and Pacific Missile Ranges of missiles with high-explosive warheads.

In the testimony just released, Secretary McNamara defended his Jan. 9 statement regarding Goldwater's charge that U.S. missiles are not dependable. McNamara said then the charge was "completely misleading, politically irresponsible and damaging to the national security."

However, in an exchange with Rep. Melvin R. Laird (R.-Wis.), McNamara quoted the dictionary definition of "dependable"—"to be able to expect performance in relation to an objective"—as the basis for his violent disagreement with Sen. Goldwater. When asked by Rep. Laird whether McNamara would "rather have had Senator Goldwater use the word 'reliability,' " the Secretary would not comment but stressed again what Goldwater had said. ■

LEM 'saddlebags' suggested . . .

Small Space Station Seen Most Feasible

by Hal Taylor

A TOP JOHNSON Administration space official has urged industry to focus its current study effort on a three- to six-man, 15,000- to 20,000-lb. space station program rather than the large 200,000-lb. spacecraft.

Thomas A. Dolan, a staff member of the White House's National Aeronautics and Space Council, also hinted that there is no need for extended *Gemini* and *Apollo* spacecraft for use as space stations because the advent of the *Manned Orbiting Laboratory* program fulfills minimum station requirements.

Dolan's comments on this country's manned spaceflight program were made at an American Institute of Aeronautics and Astronautics Symposium on Space Stations and Their Logistics Support in Pasadena, Calif.

In other highlights of his address, Dolan said:

—Use of the Lunar Excursion Module saddlebags concept might be more imaginative and cheaper as the supply system for extended lunar exploration than the planned LEM truck spacecraft.

—Space stations could be used for manned lunar reconnaissance missions before the first manned landing and also as a base for launching of many models of re-entry vehicles back to Earth in a much needed data-gathering program.

—Examination of a Mars orbiter mission as the first manned planetary flight should be emphasized rather than a Mars fly-by or Mars lander mission.

The space council official told the symposium that current space station studies are moving from the more conventional 15,000- to 20,000-lb., one-year operational criteria into the more extreme corners of the topic. "We are witnessing greater penetration of concepts that involve extension of the *Gemini* and *Apollo* at the one extreme and the large . . . 12- to 24-man space stations at the other."

Noting that the Air Force's *MOL* program appears to adequately pursue the requirements of the minimum end of the space station spectrum, Dolan said that the opposite end of the spectrum promises considerable activity and some misconceptions.

- **Large station problems**—He declared that it is not true that a large station will be no more expensive than a three- to six-man spacecraft. He also said that proponents of the large station who argue that it would not require large amounts of resupply overlook the fact that the number of resupply missions is dictated by personnel rotational requirements and not the need for Earth-based support.

"The point that I am suggesting," he continued, "is that the meaningful regime of current space station interest should continue to be in the three- to six-man sizing, in the 15,000- to 20,000-lb. weight regime and in the one-year operational capability. Rendezvous and resupply should be an integral part of the system concept."

While the space council official did not say so, it is understood that such a concept would be the "middle" regime of the space station effort, with the *MOL* program filling the minimum end. There is a possibility that the *MOL* program—which now calls for a two-man station using the *Gemini* spacecraft as a resupply vehicle—could also fill the requirements of the middle area.

A decision as to whether *MOL* will fill the bill or whether a new station will have to be developed is expected before the end of the year.

Turning to the problems of supply systems for extended lunar exploration, Dolan said that the *LEM* truck system requires multiple launches and surface rendezvous.

- **"Saddlebags" for LEM**—He proposed instead what he termed a more imaginative approach, the LEM "saddlebags" technique in which 3,000 to 5,000 lbs. of supplies would be attached to a manned Lunar Excursion Module. The system reportedly would give a 7- to 10-day staytime with a 5- to 20-mile radius of action. During the mission, the *Apollo* Command and Service modules would remain in orbit while the manned LEM with its saddlebags landed on the surface.

Such a system would increase the total *Apollo* spacecraft weight (mostly additional LEM propulsion) by 15,000 lbs.

Theoretically, NASA has growth options totaling more than 100% for the *Saturn V/Apollo* spacecraft system. Dolan said a growth of 15 to 20% was entirely within the realm of possibility.

"The LEM saddlebag concept," he said, "would avoid multiple launches, hardware development programs for unmanned landing systems, dependence on successful unmanned landing system performance prior to manned landings, and dependence on surface rendezvous. As such, the post-*Apollo* exploration phase could be carried on with higher mission success and with less total investment than that estimated for the other systems."

While NASA officials admitted they are studying the saddlebag concept, they indicated that if developed, it should serve as a predecessor, but not a replacement for the LEM truck. They admitted, however, that they expect to place study contracts of the concepts with industry soon, indicating it is being given serious consideration.

- **Re-entry role**—In discussing the use of a station to gather re-entry data, Dolan said that many models of different shapes would be carried to the station in conjunction with the normal logistics by the resupply ferry. They would be launched like the arrows from a quiver into the atmosphere and into an instrumented range, such as the Atlantic Missile Range, at different angles of attack and velocity. By this approach, hundreds of data points could be gathered on dozens of models per month as a normal by-product of an operating space station system.

For the lunar reconnaissance mission, a station would be mounted behind the service module, picking up the LEM's "hard points" for structural continuity. Upon injection—as with the LEM—the *Apollo* spacecraft would separate from the station, turn around and engage the station docking mechanism.

After lunar orbit injection, two crew members would enter the shirtsleeve environment of the station module and initiate reconnaissance. A wide range of sensors would be employed. In addition, probes would be launched to the lunar surface with impact data electronically recorded and photographically and visually observed. Beacons could be landed at selected surface points to enhance subsequent manned lunar landings. ■

Includes two Thor pads . . .

Construction Speeded At Johnston Island

CONSTRUCTION of two *Thor* launch pads and control facilities is proceeding on an accelerated schedule at Johnston Island as part of the Defense Department's commitment to maintain adequate safeguards against a sudden resumption of nuclear testing by the Soviets.

Two islands are also being created around the joint task force test site to house instrumentation and sampling rocket sites. These Pacific coral atolls are being created by dredging and are expected to relieve some of the congestion at the Johnston Island site.

Most of the construction has been financed during Fiscal Years 1963 and 1964. Total expenditure has been $37 million. The FY '63 funds came from reprogramming from ARPA's Defender program, and from one of the military services. The ARPA reprogramming has led to speculation that the construction on Johnston Island was part of a classified program to build and test an anti-satellite system. It now appears that this is unfounded.

An indication of the emphasis being put on an early operational date for these launch pads is that the Defense Department intervened last December in a concrete industry-teamster union strike which threatened to slow down shipments of pre-stressed concrete pilings to Johnston Island. The Hawaiian labor dispute had dragged on for eight weeks before DOD intervened.

Funds for the maintenance of a standby atmospheric test capability are budgeted at $77 million for Fiscal 1965. This money will be spent on the research, development, procurement and maintenance of long leadtime instrumentation and instrument carriers and support of the couple of hundred man task force on Johnston. This task force is planning and conducting the construction program.

By Jan. 1, 1966, the Defense Department feels that it will have the capability to begin atmospheric and underwater effects tests within six months of notice, stockpile proof tests within two months, operational systems tests within two to three months and weapons development tests within about three months. ■

Limited Redeye Production Ordered

REDEYE—the individual soldier's air defense missile system—has been ordered into limited production. Some three years after the first procurement funds were requested in FY '61, the Army announced the award of a $13.2-million production and engineering contract for the infrared-guided missile to the Pomona Div. of General Dynamics.

Designed to fill a critical gap in the Army's front-line defenses, *Redeye* will be effective against low-flying light attack aircraft, helicopters or an attack bomber looking for targets of opportunity. Specific tables of authorization for the guided missile have not been worked out, according to Army officials, but they indicated that *Redeye* would be deployed to company-size units. A two-man team—providing 360 degrees of protection—will be assigned to these units, probably in the weapons platoon.

First models of the missile will reach Army troops by June, 1965, with the majority of the troops receiving the weapon in 1966. The Marine Corps has budgeted $10 million in FY '65 to procure *Redeye*.

Developed at a cost of $58 million, the missile ran into problems in getting a lightweight guidance system that was sufficiently accurate to fulfill its mission. To get the weapon into production, the Army accepted some degradation in initial performance, which it hopes to recoup through a product-improvement program.

The supersonic missile is four feet long, three inches in diameter and weighs 18 pounds. Solid propelled, its motor ignites after it has been ejected from the launch tube. The launcher, which is thrown away after the missile is fired, mounts a 2.5-power optical sight with a 25-degree field of view. The launcher weighs nine pounds. The cost per round of *Redeye* was placed at approximately $3,000.

Tests at Naval Ordnance Test Station between June and December of last year against droned aircraft, jets and helicopters provided the basis for the decision to go into limited production.

Rocket motors are under contract to Atlantic Research Corp., Alexandria, Va. Miniature Precision Bearings, Keene, N.H., makes the seeker optics. ■

FIRST ACTION PHOTOS show Redeye being launched (right), about to enter drone's tailpipe (center), and subsequent explosion.

In quest of reliability . . .

Space Agency Nears Decision On Adopting Parts Qualification List

Approval expected in two to four months; pilot project involves only electronics; vendors would find listing 'highly desirable'

NASA IS CONSIDERING adoption of a so-called "Qualified Parts List" (QPL) to which firms may ultimately have to belong if they want to sell their products to the space agency.

The plan is currently under study by agency technical, procurement and legal personnel. A final decision on implementation may be made in two to four months. Informed sources say affirmative action is expected.

NASA officials report that the document, if adopted, will not be called a Qualified Parts List, but is certain to function as such in everything except name.

It has not been decided whether a firm will have to have its products on the list if it wants to sell them to the agency, but this would appear to be an academic point. As one official put it, "if the list is adopted, it would be highly desirable for a vendor to get on it." This implies that even if listing is not required, the space agency might overlook companies whose parts and components weren't part of the QPL.

The agency is currently engaged in a parts list "pilot project" costing about three-quarters of a million dollars per year. If the QPL list is approved, it is expected that it will cost about $4 million per year to maintain it.

The pilot run involved about 90 components and was restricted to electronic systems. No decision has been made yet, but it is likely that if the list is used by NASA, mechanical systems will also be included.

At this point, officials want the list to be used as a grading system for all "high-usage" parts which are purchased for space agency programs.

One official said that while the term "high usage" still has not been precisely defined, it ultimately could include hundreds of parts.

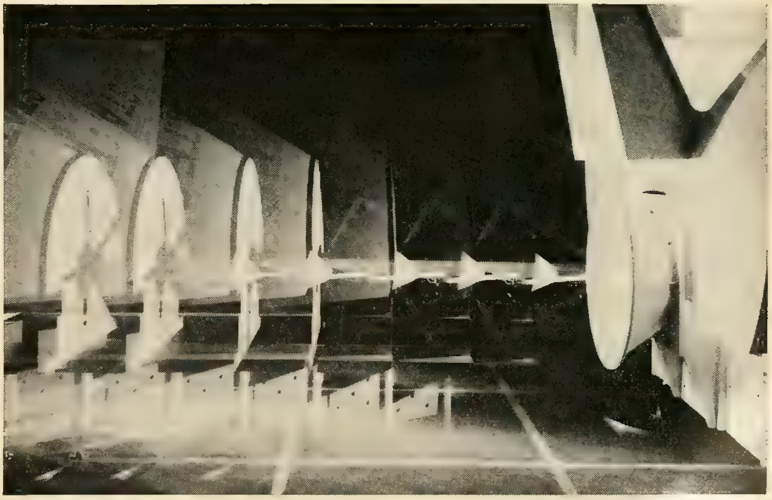
- **Sink or swim**—Agency plans call for listing the parts according to the vendor. Ratings would be based on present and past test results. These would include failure rates and data from such things as bench, lab and simulated Earth-orbit, ballistic and lunar-mission testing. The list would also contain information as to whether the amount of test data was sufficient or meager.

In addition, there would be detailed characteristics of each part, so that NASA field centers or contractors could easily identify them to make sure that they are getting the parts purchased.

It is expected that once the QPL becomes a fact, parts which do not measure up to their manufacturer's claims will be dropped from the list.

The QPL is part of a concerted NASA drive to improve reliability of components and systems to enhance the chances for successful space flights.

Another facet of the program is improvement of the "reliability and quality assurance" programs at NASA contractors. As one part of this effort, NASA recently requested proposals from industry for two contracts to develop manuals and instructional aids to educate officials at NASA field centers and contractors on good reliability programs. One of the contracts will be pointed toward hardware projects and the other to the study contractors. ■



Lunar Docking Drill at North American

EIGHT-PHOTO sequence shows probe from Apollo Command Module entering drogue of Lunar Excursion Module in technique being developed for NASA's Manned Spacecraft Center by North American Aviation's Space and Information Systems Div., Downey, Calif. Probe aligns the two modules and absorbs shock. Automatic latches lock vehicles.

Thiokol VP Urges Funding Boost For Space-Storable Propellants

by John F. Judge

MONEY—not technology—is the limiting factor in the development of high-energy, space-storable upper-stage propulsion systems, says Dr. Harold W. Ritchey, executive vice president, Rocket Operations, Thiokol Chemical Corp.

The solid propellant expert recently told the NASA Oversight subcommittee of the House Committee on Science and Astronautics, that a high-performance engine based on oxygen-difluoride with initial thrust levels in the 20,000 to 30,000-lb. range can be developed for use in five years for about $80 million.

Turning to solids, Ritchey said a continuing program should be planned and put into effect before the June, 1965, completion date of the Air Force/NASA large solids booster demonstration program is reached.

The current program calls for half-length, 260-in.-dia. solid rocket test firings by both Aerojet-General and Thiokol and ends in June, 1965.

If present plans are followed, there will be at least a six-month delay before any portion of a full-length 260-in. program is initiated, with the result that highly skilled project teams will have been dispersed.

- **Sustained effort needed**—Ritchey told the subcommittee there is a definite need to pursue high-energy propellant technology on a broad front—since there is no "best" approach for every need that can be projected.

"Our space program planning needs flexibility," said Ritchey, "and the capability of making intelligent decisions as to direction of future efforts long before those efforts are committed."

Space-storable propulsion systems are part of this picture, and Ritchey says the work at Thiokol since 1960 has established the advantage of working with OF_2 systems. The high density of these combinations together with their high specific impulses make them competitive with non-storable propellants such as liquid oxygen, liquid hydrogen and even liquid fluorine.

The temperature ranges of the storables can be established in space by passive means—eliminating tank venting systems and boil-off losses.

Ritchey said considerable progress has been made in spite of the low funding for space storables. The major conclusions of current work—both corporate funded and contracted—are that state-of-the-art ablative materials behave in a predictable manner with OF_2 combinations and that the hypergolic features are reliable over extreme environmental, operating and propellant state conditions.

In addition, the specific impulse values range in the 95 to 99% theoretical shifting equilibrium area, and the actual cooling ability of OF_2 is greater than predicted by analysis.

Firings at both 150-lb. and 2,000-lb. thrust ranges have been conducted, but Ritchey says this must be pursued at more meaningful scales—preferably 10,000 lbs. thrust.

If a more concerted effort were made to include this thrust range and to investigate feed system considerations, plus throttling and investigations of a broader range of fuels for use with OF_2, Ritchey says the FY '65 cost would be about $5 million.

- **Solids gap**—Ritchey also outlined the work schedule for the Air Force's 260-in.-dia. solid rocket demonstration program. The 156-in., 3-million-lb.-thrust motor in the program will be fired in August with the first 260-in., 3-million-lb.-thrust, 110-sec. burning time test firing in January 1965. The second 260-in. will be tested in June 1965. The program—as it is currently funded—ends there.

Ritchey says the effort should continue without interruption to cover many of the accessories required for vehicle applications. These include thrust vector controls, certain performance improvements in inert parts, implementation needed to proceed to full-scale, 6-10 million-lb.-thrust 260-in. motors and the planning and implementation of an inclusive development and pre-flight engineering effort.

Ritchey claims that with proper planning and authorization, a 260-in. short-length motor could be delivered for flight testing in mid-1966 and the full-length motor in the last part of 1967.

As part of his argument, Ritchey outlined some possible early applications for the 260-in. short-length motor. Chief use would be to fill the payload gap between the 33,500-lb. *Saturn IB* and the 220,000-lb. *Saturn V*.

The 260-in.-dia. *Saturn IB* can be modified to accommodate the short-length 260-in. solid and provide a 100-nautical-mile orbit payload range of 50,000 to 60,000 lbs.

Ritchey also cited a cost-effectiveness study recently completed by a major contractor that shows a reduction from $576/lb. to $298/lb. in orbit by using the 260-in. solid as suggested.

- **Urges program funding**—Ritchey called for a go-ahead decision by mid-1964 to cover both program scope and additional FY '65 funding authorization. The program should include the testing of at least two full-length 260-in. motors and provide for integration of TVC and other flight devices.

Ritchey's proposed transition program—designed to fill the six-month gap between the current demonstration program and a full-scale 260-in. program—would include the design of full-length motors together with structural and ballistic performance analysis.

A second portion of the interim program would call for refurbishing a short-length motor case, reloading and using it for a TVC system test. The transition program would cost about $7 million.

Ritchey estimates the cost of establishing a full-length 260-in. program for the demonstration, pre-flight engineering and flight-delivery phases at approximately $100-120 million, plus about $22 million for additional facilities.

Ritchey says this is a bargain compared to other types of propulsion.

NASA is handling the FY '65 funds for the continuation and completion of the 260-in. program. The Air Force will continue administrative contract management, while NASA will contract new work directly.

There are no firm plans for full-length follow-ons but NASA has expressed an intent to continue if the demonstration program is a complete success. ■

In House testimony. . .

Thiokol VP Urges Funding Boost For Space-Storable Propellants

by John F. Judge

MONEY—not technology—is the limiting factor in the development of high-energy, space-storable upper-stage propulsion systems, says Dr. Harold W. Ritchey, executive vice president, Rocket Operations, Thiokol Chemical Corp.

The solid propellant expert recently told the NASA Oversight subcommittee of the House Committee on Sci Astronautics, that a high-perf engine based on oxygen-difluo initial thrust levels in the 2 30,000-lb. range can be devel use in five years for about $80

Turning to solids, Ritche continuing program should be and put into effect before t 1965, completion date of the Ai NASA large solids booster de tion program is reached.

The current program calls length, 260-in.-dia. solid ro firings by both Aerojet-Gen Thiokol and ends in June, 196

If present plans are follow will be at least a six-month del any portion of a full-length 26 gram is initiated, with the re highly skilled project teams been dispersed.

- **Sustained effort needed**— told the subcommittee there is need to pursue high-energy p technology on a broad fro there is no "best" approach need that can be projected.

"Our space program plann flexibility," said Ritchey, "an pability of making intelligent as to direction of future eff before those efforts are com

Space-storable propulsion are part of this picture, and says the work at Thiokol si has established the advantage ing with OF_2 systems. The hig of these combinations toget their high specific impulses m competitive with non-storabl lants such as liquid oxygen, l drogen and even liquid fluori

The temperature ranges o ables can be established in space by passive means—eliminating tank venting systems and boil-off losses.

Ritchey said considerable progress has been made in spite of the low funding for space storables. The major conclusions of current work—both corporate funded and contracted—are that state-of-the-art ablative materials behave in a predictable manner with OF_2 combinations and that the hypergolic

short-length motor could be delivered for flight testing in mid-1966 and the full-length motor in the last part of 1967.

As part of his argument, Ritchey outlined some possible early applications for the 260-in. short-length motor. Chief use would be to fill the payload gap between the 33,500-lb. *Saturn IB* and the 220,000-lb. *Saturn V*.

The 260-in.-dia. *Saturn IB* can be modified to accommodate the short-length 260-in. solid and provide a 100-

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Technical Countdown

ELECTRONICS

Phoenix to Use IR Homing

Infrared sensing in the *Phoenix* missile is carried out with an eight-element lead sulphide array, coupled to eight individual integrated-circuit amplifiers. Originally, Hughes Aircraft Corp., chief contractor for the TFX's missile, considered using a single slab of amplifiers mounted on the back of the sensor array. This technique, however, is considered beyond the present state of the art, and individually packaged amplifiers in ⅜ in. x ¼ in. packs are used instead.

Control Lags Behind Observation Accuracy

Although radar data surpass on-board observations for spacecraft trajectory estimates, midcourse-connection fuel savings using radar would be negligible in comparison, since both approaches provide accuracies better than that obtainable from the control system. So say two NASA scientists. The performance in achieving optimal velocity corrections, claim G. L. Smith and E. V. Harper of Ames Research Center in a recently published NASA Technical Note, is ultimately limited by mechanization errors during midcourse maneuvers.

Radio Telescope Pair Completed

Installation of the new 240-ton, 85-ft.-dia. paraboloidal antenna at the National Radio Astronomy Observatory, Green Bank, W. Va., has been completed. The mobile radio telescope, built by Blaw-Knox Co., will be used with a previously installed fixed antenna of the same size for interferometry use in space observations. After an extensive calibration program, the paired antennas will be employed in the study of positions, sizes and approximate intensity distributions of radio sources in outer space. Angular resolutions to less than 10 seconds of arc will be possible, Blaw-Knox said. Observing frequency will be 2,695 mc.

TV Tube Sees Movement in Dim Light

A development of the vidicon camera tube with a speed of response independent of light intensity will be marketed in the U.S. at the end of this year by NV Philips Gloeilampenfabrieken, Netherlands. Called the "Plumbicon," it makes use of an evaporated layer of microcrystalline lead monoxide instead of antimony trisulfide. The lead oxide photosensitive film has a thin "P" layer on the gun side, an "N" layer on the light source side and a central region of pure intrinsic semiconductor. Operating in the reversed-biases direction, this P-I-N diode has a dark current of a nanoampere and a constant gamma of between 0.8 and 1.0. Maximum sensitivity is at 5,000 Angstroms. Research into an infrared sensitive version of the tube is underway at Philips. Dr. E. F. de Hann, describing the tube to the 95th conference of the Society of Motion Picture and Television Engineers in Los Angeles, said that the Plumbicon would be especially suitable for light-weight color television cameras or for viewing movement at low light levels.

MATERIALS

Parachute Deterioration In Space

Possibility that nylon parachutes may deteriorate in space and so endanger the safe landing of spacecraft is suggested by test-chamber work carried out by Northrop Ventura, Newbury Park, Calif. After two weeks at vacuum pressures of 7.5 x 10^{-8} torr, nylon showed a reduction in strength of up to 20%. A return to within 2.3% of original strength occurred after seven minutes exposure to normal atmosphere. *Apollo* and *Gemini* parachutes have been designed with a large factor of safety that should take care of any loss of strength remaining after re-entry. More serious problems are likely in recovery parachutes for the *Manned Orbiting Laboratory*, where the nylon would be exposed to the effects of vacuum and nuclear radiation.

Lowest Pressure Vacuum System Readied

An interplanetary vacuum system developed and patented by National Research Corp. is being installed at NASA's Manned Spacecraft Center in Houston. The XHV system reaches pressures beyond the scope of known gauges —below the 10^{-15} torr range—and is guaranteed at the 10^{-13} torr level by NRC. The entire system is 7 ft. long and 3 ft. in diameter with a working region about half this size. The chamber is equipped for cryogenic cooling using gaseous helium at −442° F and liquid nitrogen. The unit is the first of the NRC devices to be shipped to a customer.

Cryogenic Shock Tube Delivered

Nuclear rocket components will be subjected to momentary temperature drops from room temperature to −320° F at 660 psi in a stainless steel chamber fabricated by Bobinchuck Machine & Tool Co. The 12-ft-high, 2-ft.-dia. pressure vessel was built to ASME specifications for Westinghouse Electric Corp. More than 4,000 lbs. of flawless 304 stainless steel forgings were supplied by Allegheny Ludlam Steel Corp. in the crash manufacturing program.

Mag-Lith Standard in Lockheed's Agena

A magnesium-lithium alloy developed by Brooks & Perkins, Detroit, is being used as a standard structural metal in the Lockheed-Built *Agena* space vehicle. The alloy, with a specific gravity of only 1.35, cut 50 lbs. in one *Agena* program. The metal is used where low temperatures and low stress requirements prevail. The LA141A alloy is in production at B&P's Livonia, Mich., mill and is supplied as sheet and plate. Both Battelle Memorial Institute and Dow Chemical Co. have conducted development programs into the alloy family.

ASTRONAUTICS

Water Vapor Found on Venus

Definite evidence of the existence of water vapor around and on the planet Venus in quantities comparable to that in the upper atmosphere of Earth has been found by Dr. John Strong, director of Johns Hopkins Astrophysics and Physical Meteorology Labs. Working under Air Force contracts, the Baltimore scientist made the determination from a robot telescope system flown to an altitude of 87,500 ft. via balloon. Spectroscopic measurements were made over a two-hour period in the daylight flight. Since it is known that CO_2 exists on Venus, says Strong, the proof of water vapor forces a re-examination of every previous calculation made concerning the possibility of some sort of Venusian life. Strong's work is being sponsored by the Office of Aerospace Research.

NASA Picks Large Station Design Calling for Three Radial Modules

by Rex Pay

ANAHEIM, CALIF.—The large space station design selected as most promising by NASA is a 150-ft.-dia. three-radial-module configuration, rotating at a maximum speed of 4 rpm and carrying 24 men.

It would have a life of one to five years and would be put up in a single launch by a two-stage *Saturn V*. *Saturn IB* boosters would be used to launch logistics vehicles.

Total cost of the station is put at several billion dollars. A development time of four to four and a half years to launch is forecast.

Further studies on particular problem areas in this design and on evaluation of potential experiments are to be funded before the end of this fiscal year. Both follow-on contracts and RFP's are likely to be issued soon.

NASA's studies of large manned space stations show that the configuration chosen would have a cost-effectiveness of $10,000 per useful man hour. In comparison, the same studies show that a small four-man orbital laboratory would cost about $250,000 per useful man hour.

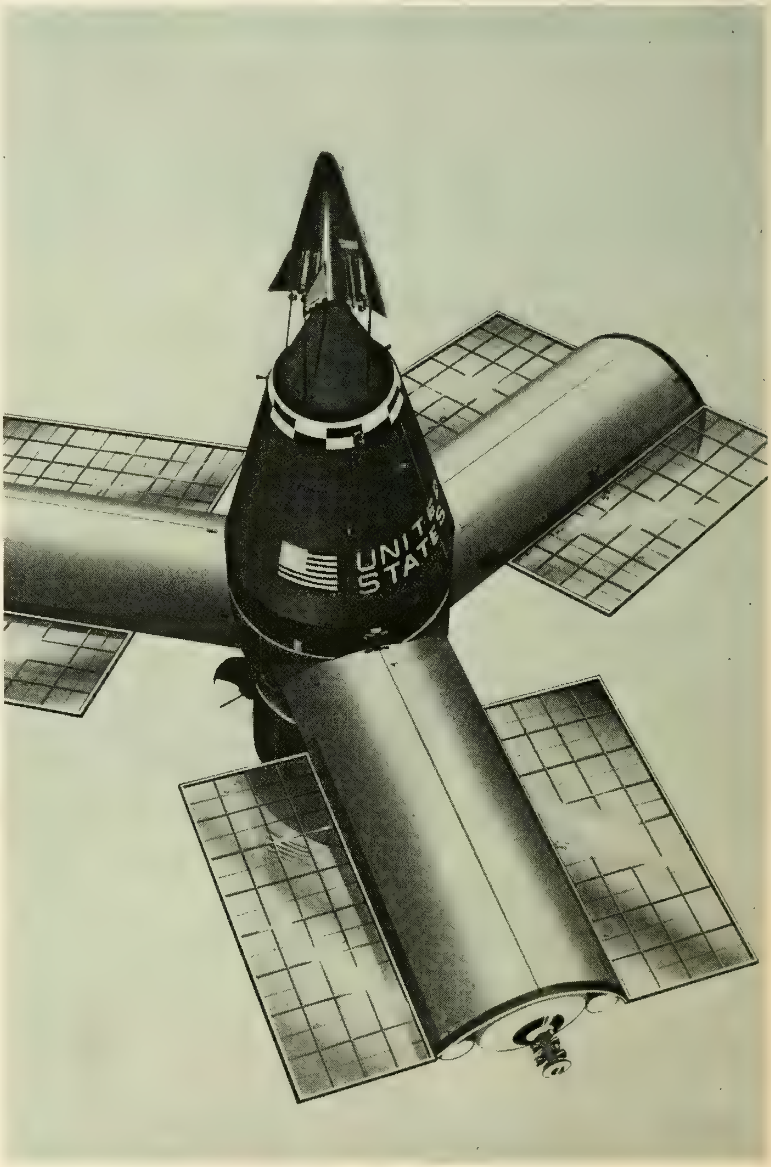
The difference comes about chiefly because members of a small crew in a small station spend much of their time maintaining and operating the station, with only three or four hours available for useful experiments.

- **Concept outlined**—Describing the present concept of the station before the Orange County (Calif.) Section of the American Institute of Aeronautics and Astronautics, Edward H. Olling, head of the Space Station Program Office, Spacecraft Research division, NASA Manned Spacecraft Center, Houston, said that the following ground rules had been applied:

—No major orbital assembly was to be attempted. This is considered beyond the state of the art;

—Orbital life was to be one to five years, with continual manned operation;

—A 250-mi. orbit with *Mercury*-type inclination was to be used to take advantage of existing range facilities.



PRESENT NASA concept of large manned station. HL-10 logistics vehicle is at top.

—Both zero-g and partial gravity were to be provided to find out what man needs over long periods;

—A single compact launch configuration was essential, compatible with existing and planned launch vehicles, pads, networks and programs.

Application of these ground rules, said Olling, has led to a space station that is less technically demanding than *Apollo,* and less costly.

One of the biggest problems will be developing instruments, he predicted. This may be more difficult than putting the station up.

● **Compatible with planned programs**—When mounted on a two-stage *Saturn* booster, the space station would stand as high as the *Apollo* spacecraft. It could therefore use the same launch complex. In the launch position, the radial arms of the space station are swung downward, parallel to the booster axis, and enclosed in structural shrouds.

Manning and supply by the *Saturn 1B* would be from a pad that will become available during the *Apollo* program. Either a ballistic or a lifting-body vehicle could be used.

The basic mission sequence following launch would be separation of the first stage, injection of the station into orbit, and rendezvous with the logistics vehicle. The space station would then be checked out, deployed, and rotation started.

Major programs for the space station will be exploitation of orbital space, planetary mission support, lunar base logistics support, and overall long-range manned spaceflight program support.

Olling said that programs up to *Apollo* were basically exploration, but that with *Extended Apollo* and the large space station, exploitation of space would start.

He considered the space station an essential step before manned planetary exploration or lunar exploitation, because it would give design data on man's requirements during long periods in space.

He put establishment of a lunar base at a lower priority than planetary exploration.

● **Station design**—The 24-man crew is the basic size needed to operate the station. They provide, on the average, 150 useful manhours per day. A considerably larger crew could be carried if need for it could be justified.

The natural lifetime of the station is one year, provided full advantage is taken of redundant techniques, the crew's ability to carry out repairs, and the ability to supply spare parts from Earth.

Olling said that one of the most critical features of present space technology, as far as manned spaceflight was concerned, was the absence of design for repair. Most assemblies, he said, are very difficult to repair in a well-equipped factory on Earth; they are impossible to repair in space.

He is sure that a program will have to be initiated to study components used in space stations from the point of view of their repairability and their potential use as an exchange part for another system in the spacecraft.

Repairability is likely to become of paramount importance in manned interplanetary probes, where there is no chance of a rapid abort if something goes wrong.

● **Module details**—The three radial modules of the space station will contain living and working quarters some 15 ft. in diameter and 60 ft. long. Five-foot diameter tunnels will give access to the central hub, which would be counter rotating to give a zero-g laboratory.

Being located in the plane of rotation, the modules provide a variation of 0.2 to 0.4 g along their length.

This form of rotation was selected as the most economical and most stable. Olling said that unpleasant physiological reactions to Coriolis effects were not expected, as observations on merry-go-round operators show acclimatization takes place. Various rates of rotation will be tried for experimental purposes.

Each radial module would be divided along its length into a number of rooms with 7-ft. ceiling height. In general, the outer room (highest g) would be the crew's living quarters, the next would be a laboratory area, the third an applications area, the fourth would contain space station systems, and the rest would be for storage.

Electrical power—upwards of 25 kw—would be supplied by solar panels.

● **Weight considerations**—Total weight of the station could approach 200,000 lbs. Total volume would amount to about 55,000 cu. ft. A two-gas atmosphere is likely to be used, with capability for varying the pressure between 3½ and 14 psi. The carbon dioxide content may be varied for experimental purposes.

About 3,000 lbs. of propellant would be needed to maintain orbital altitude during a year.

A docking hangar for spacecraft would be located under the zero-g laboratory in the central hub. These spacecraft serve as life boats in emergencies. The logistics vehicle docks at the other end of the hub, its crew entering the station through a tunnel in the conical non-re-entering cargo compartment.

Various types of re-supply spacecraft have been considered: a modified *Apollo* logistics vehicle to take six men instead of three, the Ames M-2 lifting vehicle, carrying 12 men and 14,000 lbs. of cargo, and Langley's HL-10 lifting-body design.

Important advantages of lifting-body vehicles are their horizontal landing capability, their re-usability, and their large footprint. Olling said that while a ballistic vehicle could return from the station to its base once every 12 hours, a lifting body could return once every three to four hours.

● **Selecting experiments**—To select experiments most suitable for the space station, the following criteria have been set up. Experiments are needed in which man is the subject; or experiments that require man to perform a calibration, monitoring, or repair function; or experiments in which a true space environment is required, even if man's presence is not mandatory.

Scheduling of experiments will be based on their priority with respect to long-range space programs, on their requirements of weight, volume, crew participation, and power (no experiments have been rejected on this score yet), and on their ability to share equipment.

Various categories of work have emerged from the one thousand experiments that have been suggested for the station.

First category is basic research, involving experiments in astronomy, cell growth, basic chemical reactions, exploration of the geodetic environment, and similar topics.

● **Crew-oriented research**—In applied research, the second category, typical studies will be concerned with the physiology and psychology of the crew as a necessary preliminary for lunar exploitation or planetary missions. Studies will also be made of the space environment—on radiation and meteoroids, for instance.

In another category, engineering development and qualification, all the various systems required in space will be developed and tested under realistic conditions. Systems for specific programs will be tested over long periods for reliability.

Applied orbital functions—astronomical, meteorological, navigational, and communications activities—form another category of work. Olling said that in this the manned space station would not usurp the role of unmanned satellites, but would do work where man's ability to make adjustments could be used.

Another category of work on the space station would be orbital activities and operations. These include crew selection and training for future missions and orbital assembly and support of planetary spacecraft.

Finally, the space station would be available for Defense Department applications, such as surveillance and reconnaissance. ■

FROM LOCKHEED RESEARCH

A workboat to explore the depths

There's treasure in the deep. Oil, gold, diamonds. Solid chunks of manganese strewn thick on sweeping stretches of ocean floor. Sunken hulls of galley and galleon, schooner and steamship. But all today far below man's deepest reach. • So it's high time for the Turtle, first practical undersea workboat, now under development at Lockheed Missiles & Space Company. Lockheed scientists—making new use of the advanced knowledge of hydrodynamics they acquired in perfecting the Navy's Polaris missile and of their experience with closed-cycle life-support systems for Outer Space—have designed a unique undersea hull for Turtle (that's an apt name for her). She'll power herself down, down, down to the scene of her mission. • No cramped-quarter bathysphere, she! Turtle supports her crew in spacious comfort, months on end. Room for all kinds of black-box gear. Cargo space for the treasures she'll glean. • Defense possibilities? Definitely! As a mobile and virtually undetectable long-range-sonar outpost. As a search-and-rescue ship for disabled submarines. • Lockheed scientists have many new ideas about this vast Saltwater Space below us. You'll be hearing more of them.

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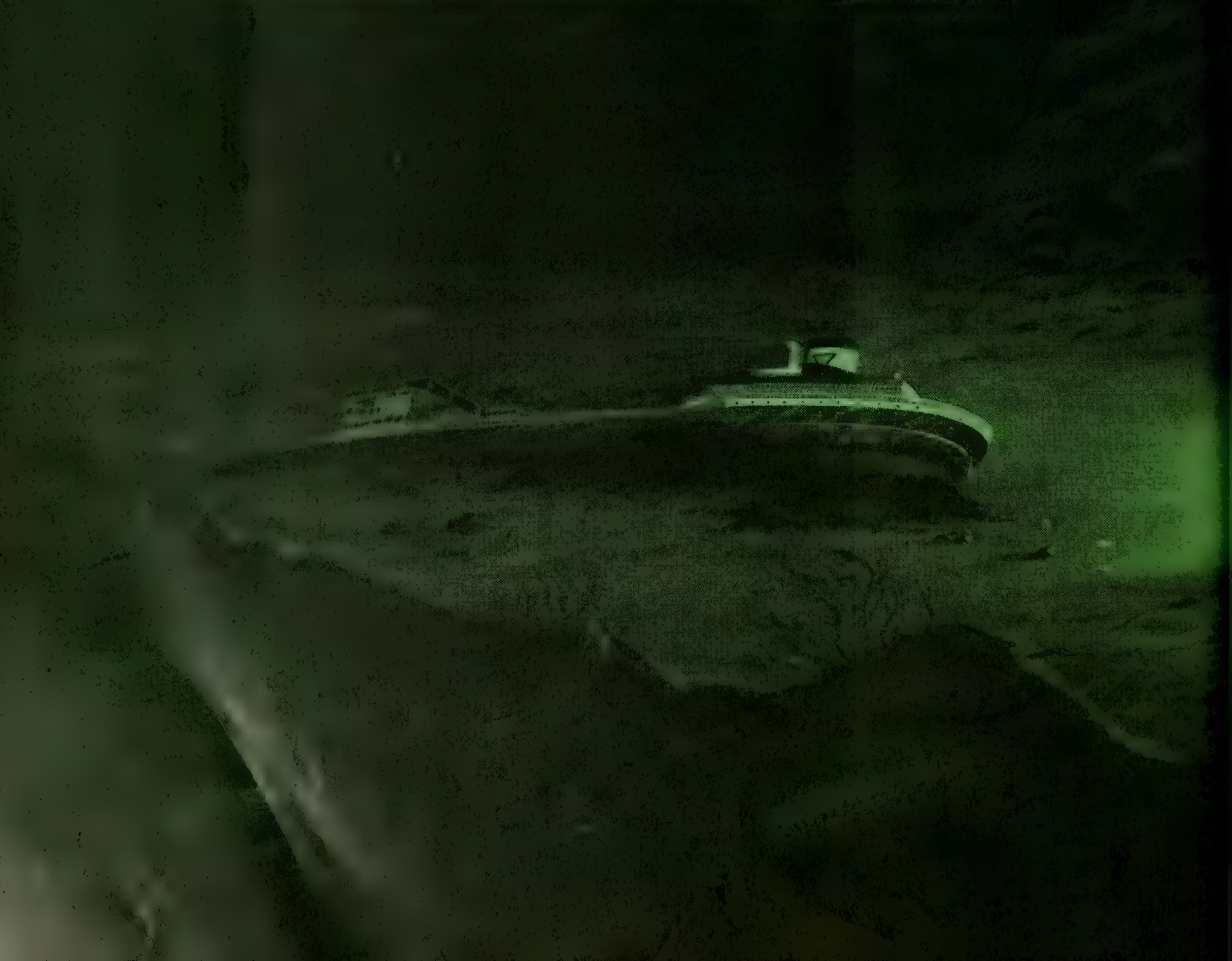


AEC Confident of Tory II-C Design

Officials believe technology for LASV propulsion now available; military, DOD and Budget Bureau must decide on flight testing

by Willard E. Wilks

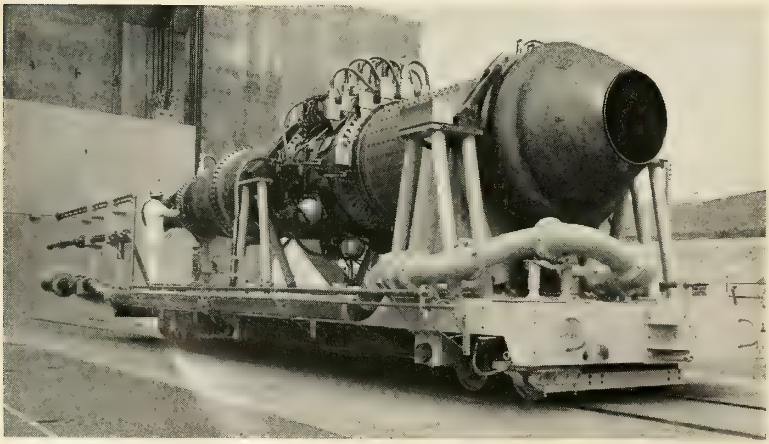
ATOMIC ENERGY Commission officials are confident forthcoming tests of the flightweight Tory II-C reactor will prove that the technology for a nuclear ramjet to propel a global-range *Low Altitude Supersonic Vehicle* (*LASV*) is now in hand.

"The next move, going ahead with a flight test vehicle, is up to the Air Force and Department of Defense," a spokesman said.

Confidence is such that Dr. Harry L. Reynolds, Nuclear Propulsion Div. leader, Lawrence Radiation Laboratory, told MISSILES AND ROCKETS: "If we had a missile for it, it (the reactor) would fly it."

Tory II-C, recently moved from the laboratory to the Nevada test site, is scheduled for full-power tests during spring and summer.

Pointing out that the smaller, 150-megawatt Tory II-A reactor proved Pluto's technical feasibility earlier, Reynolds said AEC would use Tory II-C, with a design power of 600 Mw, "if we had to fly a test vehicle in as short a time as possible. If we had a little more time, we would make improvements (on it), and if we had more time, up to a year, we would use Tory III. It's a matter of what you want—economics, (or adherence to) the time schedule."



TORY II-C reactor in its test vehicle at AEC's Nevada Test Site. For full-power testing, it will be positioned in 57-in. by 40-ft. metal duct.

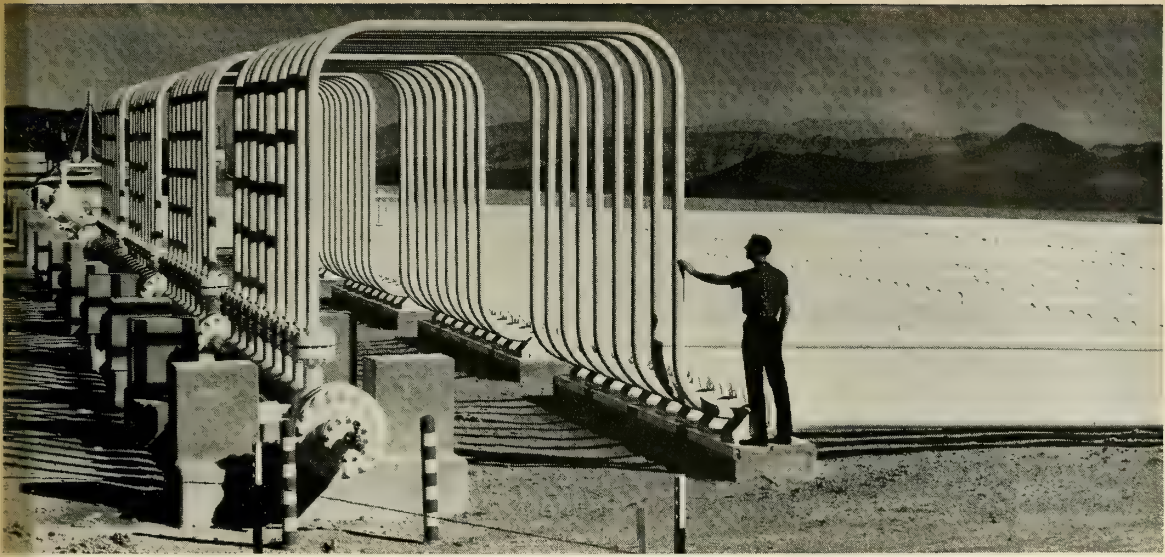
One AEC official, who described Tory II-C as "in better shape than the Kiwi reactor," said the state of development of the present Pluto reactor is such that "if it was a matter of proceeding on the urgent basis that we did with the *Atlas* ICBM, we could go ahead with what we have."

He added, however, that he "could not excuse, at this moment, a full weapons system type of approach, since Secretary McNamara has said we presently have all of the systems we need. However, I think we should continue the development program. This can provide a very powerful weapon."

Reynolds said he considered work on the other portions of the *LASV* (formerly *SLAM*) project—the vehicle, under Air Force contract to Ling-Temco-Vought, and the propulsion system, on which Marquardt Corp. is principal subcontractor to LTV—to be in about the same state of advancement as that on the reactor.

A spokesman for Marquardt, which is responsible for the inlet and, with ACF Industries, the nozzle, said, "we are no better or worse at this stage than *Navajo* was."

Considerable design work has been completed on Tory III, but no work is being conducted on the advanced reactor at present, according to Reynolds. AEC currently has funds to carry out work on Tory II-C, with completion scheduled a year from July.



AIR STORAGE and heater system for Tory II-C ground testing simulates flight conditions. Some 25 miles of piping has total of 1,200,000 lbs. of compressed air.

The Tory III design would produce more thrust per unit area of reactor and incorporate higher reliability, according to LRL spokesmen.

- **Flight test up to other agencies**—If the forthcoming tests are as successful as the AEC managers believe they will be, the big question will become whether the military, DOD and the Budget Bureau will approve a flight test program on the basis that an *LASV* capability is needed in addition to the present defense provided by the ICBM force.

Those close to the Pluto program, including AEC spokesmen, believe there is no doubt about the necessity of a flight test program following completion of Tory II-C work. They see an unlimited-range weapon that can sneak under enemy radar as a necessary complement to the ICBM arsenal—a hedge against the possibility that the ICBM will become vulnerable to an anti-missile missile, an answer to the decoy and maneuvering warhead problems.

- **Nuclear system enjoys weight edge**—The Air Force also is considering a chemical propulsion system for *LASV*, but has admitted that a nuclear powerplant for the vehicle remains more desirable.

"Fissioning of one pound of uranium can produce as much heat as the burning of 2 million pounds of jet fuel," AEC points out, "and therefore the weight of nuclear fuel expended is insignificant."

Using a reactor as a heat source and air as a propellant, such a vehicle, in addition to unlimited range, eliminates the conventional fuel and tank system, permitting a much higher payload capability in addition to reducing the severe drag encountered at low-level Mach 3 flight.

An additional advantage of the nuclear *LASV* concept is that a single vehicle able to carry multiple payloads with which to bomb widely separated targets in a single flight, and capable of maneuvering to do so, would equal a number of ballistic missiles.

- **Tory II-C description**—AEC describes Tory II-C as a full-scale, missile-size reactor with the design power, temperature and size necessary for a propulsion system for an *LASV*-type system. It is an intermediate neutron energy range reactor fueled with a homogeneous mixture of urania-beryllia.

The core consists of several hundred thousand urania-beryllia ceramic elements, each about 4 in. long and hexagonal in shape with a circular hole for air passage. The core is assembled into a cylindrical vessel duct section 103 in. long with a 57-in. outside diameter.

During operations, the reactor is placed within the test vehicle duct, a 57 x 47-ft.-long section of metal ducting fabricated of Hastelloy-C, a high-strength, high-temperature nickel-chromium-molybdenum alloy. Electro-pneumatically actuated control rods are positioned within the reactor vessel. The test vehicle duct is mounted on a specially constructed railroad car for movement to the test bunker.

Only the reactor is flight capable, the rest of the test device being mere plumbing for testing purposes. The reactor will be run at full power for periods up to 5 minutes with simulated ramjet aerodynamic conditions.

To accommodate the Tory II-C program, facilities used during the Tory II-A test series have been expanded to provide a tenfold increase in the heated air supply. Main additions include a compressor plant and storage pipe farm to store 1.2 million lbs. of air at 3,600 psi, and facilities to heat process air to temperatures up to 1,250° F.

During testing, the high-pressure air is furnished to the test vehicle inlet duct at the rate of 2,000 lbs./sec. at 350 psi and at a temperature of 1,060° F. Several 5-minute test runs are planned in the series.

Operating at full design power, equal to about half the power output of Hoover Dam, the reactor will burn 1 lb. of uranium in a 24-hr. period. The critical mass of Tory II-C is classified. It is described only as "considerably larger" than Tory II-A, which utilized 100 lbs. of uranium. Through a series of four power runs, the II-A reactor performed successfully at operating temperatures of more than 2,000° F.

Tory II-A, like II-C, was a direct-cycle air-cooled reactor fueled with highly enriched uranium homogeneously mixed with beryllium-oxide. But since it was not a flight prototype, the core was made as small as possible, it was surrounded externally by a thick graphite reflector and control was achieved by means of neutron poisons in the reflector rather than by rods piercing the core.

Design and operation of Tory II-C's control system is called a "neat trick," since they must operate within the duct at 1,000° F. and be radiation tolerant. The system provides for automatic regulation of the reactor, with a capability of manual operation when warranted. ■

NASA Studies Locomotion, Protection

AN EXTENSIVE PROGRAM in extravehicular locomotion and life support systems will be carried out by NASA's Office of Advanced Research and Technology (OART) during the next year.

Biotechnology and Human Research chief Dr. Eugene B. Konecci says the office will let a number of contracts leading to breadboard hardware on suits, life support systems, and equipment to protect against micrometeorites and radiation. Other studies on propulsion and control equipment will be carried out in conjunction with other offices in OART.

Konecci's office is now in the process of "digesting" a voluminous study which details problem areas in the whole area of manned locomotion and protection systems for the Moon, Mars and Venus. Several contracts let by Manned Spacecraft Center also will contribute data. In addition, the office is waiting to look at results from a related Air Force study before making contract plans.

In general, Konecci told MISSILES AND ROCKETS the office will be interested in space operations, surface operations on the Moon, and operations on planetary surfaces—in that order of priority. Concurrently with equipment studies, NASA will be looking for "inexpensive but meaningful" methods of simulating zero- and one-g environments, similar to those now in use at Langley Research Center.

- **Recommendations made**—The across-the-board study made by Bell Aerosystems concluded that for most tasks, especially on the lunar surface, a powered surface-contact vehicle with a supplemental rocket-propulsion device would provide the best means of locomotion.

Eighteen tasks were studied, and these conclusions were drawn:

—*Visual inspection of inaccurate landing of supply spacecraft in an unsurveyed area*—This mission is best suited for rocket propulsion unit application.

—*Supplement survey details, long distances*—Higher-resolution surveying and mapping than can be accomplished by an orbiting vehicle might be desirable. Some powered vehicle with payload capability would be best.

—*Obtain soil and rocket samples from inaccessible areas*—This could be accomplished by a propelled vehicle, or by man with or without a propulsion unit.

—*Surveying of unexplored terrain in the immediate area*—Before supplies are unloaded, the area surrounding the landing area would require exploration. This could be accomplished by a man walking, a man with an unpowered vehicle, or one with a rocket-propulsion unit.

—*Retrieving supply vehicles*—A man with a propulsion unit could identify the landing site; then a contact supply vehicle would be used to retrieve the supplies.

—*Lunar escape vehicle*—This would be unique to the propulsion unit, with high-energy propellants and large propellant weight-carrying capability. It is somewhere in the future, the study indicates.

—*Marker placement*—Perhaps is best suited to the man with an unpowered vehicle or walking with or without a protective enclosure. This would include identification of surveyed areas and beacon placement in selected areas for supply vehicles.

—*Geologic sampling missions*—Rocket propulsion units rank high; man with an unpowered vehicle also would be sufficient.

—*Conveyance of supplies*—A surface-contact vehicle will be essential.

—*Detailed mapping and surveying*—It would be best accomplished by a surface-contact vehicle capable of carrying a manned propulsion unit. The surface vehicle would travel to the area, and the man with the rocket belt would attain the altitude to perform the mission. This combination of vehicles would also best be suited for emergency return to the main shelter, the report said.

—*Deep crater exploration*—In this work, of interest for both selenological and atmospheric sampling, the manned propulsion unit is again best suited, Bell said.

Thus, Bell ranked the various modes of transportation in this order: 1) powered surface-contact vehicle with supplemental rocket-propulsion device; 2) rocket-propulsion device with payload-carring capability; 3) powered surface-contact vehicle; 4) rocket-propulsion device without payload capability; 5) man-powered surface vehicle; 6) man walking with or without protective enclosure; and 7) ground-effect machine.

The report virtually ruled out man-powered locomotion, or any mode in which the man walks or propels a vehicle across the surface by his own muscle power. Metabolic heat loads would become too great, the researchers said.

Bell Aerosystems itself has conducted over 100 flight tests with its small one-man rocket lifting device, which utilizes a hydrogen-peroxide engine producing 300 lbs. of thrust. The company claims 100% reliability.

- **Life support**—After studying literature on pressure-suited subjects attempting space maintenance tasks, the researchers concluded that pressure suits increase the time, complexity and energy required. Thus, some consideration should be given to the idea of using a protective enclosure with a higher-than-standard atmospheric pressure, in which the pressure-suited astronaut could then operate.

The Bell study estimates that industrial limits for radiation (0.1 rem for one day, 0.3 rem for one week, 5.0 rem for one year and 25.0 rem for lifetime) would be exceeded only in a trip to Mars.

Even this would not result in physical harm if performed only once in a lifetime. However, the study did not include solar flares.

Micrometeorites will present some problems, the study concluded. It was considered probable that on the lunar surface one penetration through the space suit would occur within 40 Earth days—more than twice the probability of automobile accidents on Earth. As with automobile accidents, Bell pointed out, the majority will not be fatal. However, the results will depend upon processes after perforation of the spacesuit by a micrometeorite, gas composition within the volume affected, wall design, and magnitude of volume.

The box-type enclosure over the man would provide micrometeorite protection without a great increase in weight, the study suggested. Special bumpers, honeycomb structural construction and optimum geometric shape should be studied further.

The same portable box or shelter could offer a solution to thermal problems on the Moon. ■

Aerospace Stocks Regaining Strength

Consensus is that Cold War thaw accounted for lower 1963 prices; most analysts don't foresee disarmament soon

by Michael Getler

NEW YORK—Corporate securities commonly lumped together under the heading of "aerospace" in stock market indices have begun to stir new investor interest, reflected in higher prices during the first quarter of 1964.

The upswing, if it continues, will mark a major reversal of form for space and defense issues, which took a bad battering during 1963 despite the strong upsurge in stock prices for most of U.S. industry (see chart).

Many Wall Street analysts were not at all surprised to see the recovery begin. Investment counselors, noting the selling prices to which many aerospace issues had been reduced, and also taking a hard look at the entire space and defense environment, late last year began touting selected companies in the field as attractive buys.

The feeling of a considerable number of analysts was, and still is, that investors had over-reacted to news affecting the space and defense business during 1963, thus forcing prices to less-than-realistic levels. This has happened before to aerospace issues, almost always reflecting an easing of tensions between the U.S. and the Soviet Union.

1963 was the year of the test-ban treaty and the proposal for a joint U.S.-USSR trip to the Moon; the year NASA's fiscal requests were badly slashed and the *Skybolt* missile was cancelled; and a year in which the scientific and defense aims of the nation were intensively debated within the press and Congress.

Above all else, it was a year which saw the apparent creation of an environment for a future disarmament agreement with the Soviets. This issue most affects the long-term price supports for aerospace securities.

- **A time to buy**—However, many advisers declare (after emphasizing that they regret the fact) that they do not see any major disarmament agreement in the U.S. future.

For example, in a speech to the National Association of Investment Clubs late last year, Arch C. Catapano of Merrill Lynch, Pierce, Fenner & Smith, Inc., said: "It is our view that the current prices of leading aerospace shares are discounting a contingency—disarmament—which is not likely to develop over the foreseeable future. At current levels, many aerospace shares are selling at relatively modest price/earnings ratios and represent attractive buying opportunities. It should be observed that declines which attended past periods of relaxation in cold war tensions usually presented excellent timing for making commitments in the group."

In a year-end research study of the airframe systems industry, the investment banking firm of Donaldson, Lufkin & Jenrette, Inc., (DL&J), based its comments on future trends in government spending for space and defense "on our belief that world disarmament is not a practical reality during this decade," and that the U.S. "will require maintenance of a strong defense capability at about current levels. The leading companies in this field," the report continues, "are currently selling at their lowest average multiples in years."

Yet, "the near-term prospects for many of these companies have seldom been better. Although risks are inherent in the industry, in our opinion these risks are less than the market appears to believe. Once these risks are put in proper perspective, we expect a higher valuation will again be placed on these stocks."

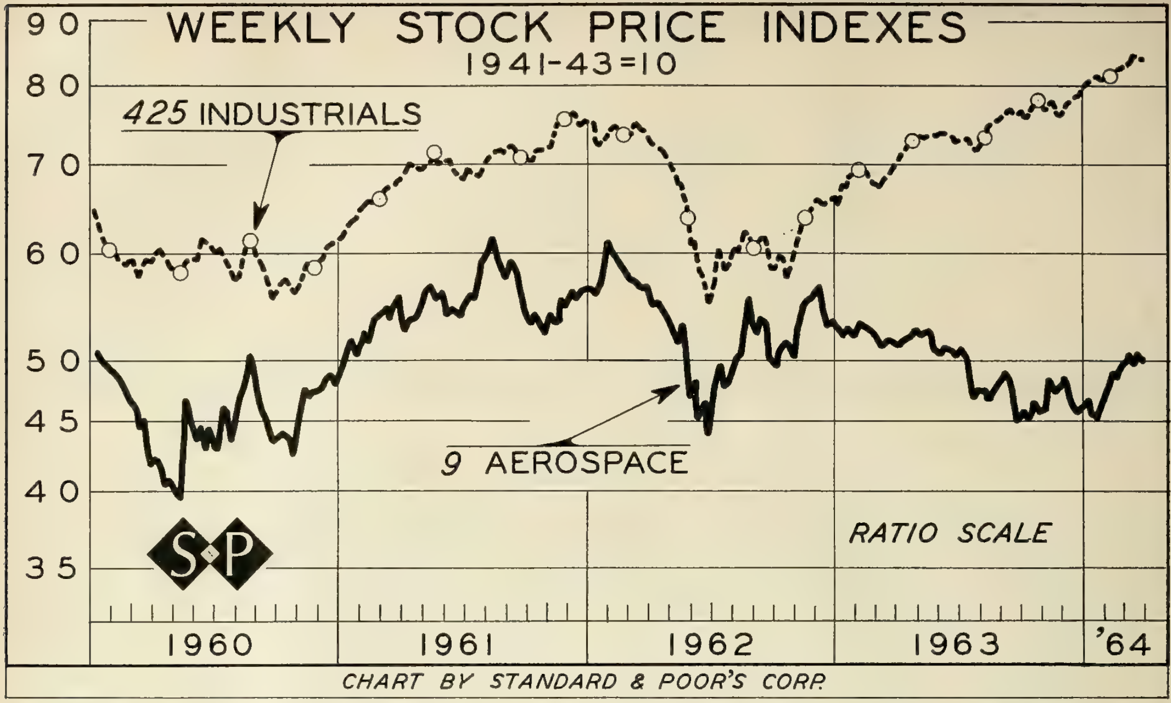
- **Plateau seen**—Though accepting the possibility of a near-term decline in appropriations for the aircraft industry, over the long term the firm sees a 1970 defense and space budget in the $72-78 billion range. If the aircraft industry can increase profit margins from 2.3% to 2.5%, which the firm sees as a realistic goal, "they will compensate for our maximum expectation of a near-term 10% decline in defense expenditures."

In its 1964 commentary on the aerospace industry, National Aviation Corp., a closed-end investment company, states: "What lies ahead in both (DOD and NASA) areas promises to be a plateau in spending, rather than an appreciable decline, provided events beyond U.S. borders permit. To repeat the late President's words, 'This is a dangerous and uncertain world.' In that view, the financial burden of our defense and space programs is simply not susceptible to major curtailment."

In a series of reports written last year on one major aerospace prime contractor by the Wall Street firm of Baker, Weeks, & Co., the author, noting the complicating factor of Communist China in addition to the usual references to the Soviet Union, says "it seems realistic, while unfortunate, to expect a continuation of high defense budgets, which will change in emphasis as needed to react to world situations."

- **Negative voices**—There is a sizeable body of opinion in support of this view, but there also is strong opposition. The merits of buying any space or defense issue, as opposed to similar investment in the commercial sector of industry, is still vigorously debated. However, the reasons supporting the arguments have changed somewhat in the past year or two.

There has always been a certain reluctance on the part of investors—particularly more conservative buyers



such as trust fund holders, insurance firms and university endowment funds, all of which control large sums of capital—to pour monies into the defense stocks because of the inherent problems of doing business with a single government customer. In the past year, in particular, this has been compounded to a great extent by the overriding issue of disarmament.

The opposing viewpoint was expressed to MISSILES AND ROCKETS recently by Frank Reinhardt, a vice-president with Standard & Poor's Investment Advisory Dept., which for the past year has not recommended purchase of defense issues. This recommendation is still intact.

"It isn't worth it," Reinhardt says. "If this investment business is one to minimize your risk, why take these chances with the defense business? There is no harm in avoiding the defense issues, even if we are wrong, as long as we are smart and successful in other sectors. We should have spotted McDonnell Aircraft," he admits, "but we're not sorry."

Although the entire Wall Street community is aware of certain risks associated with aerospace issues, very few advocate an across-the-board avoidance of these stocks.

• **East-West trade**—Reinhardt, pointing to signs of increased U.S. trade with the Soviets, feels that there is certain to be some kind of accommodation that must reflect upon the defense business.

Many Administration economists, and Commerce Secretary Luther Hodges, now openly support increasing trade with the Soviet bloc in "non-strategic" goods, even including heavy machinery for refineries and agriculture. In a move which could drum up pressure, the government recently released trade figures for 1962 which showed that the U.S. conducted some $125 million in trade with the Sino-Soviet bloc in comparison with $4.7 billion on the part of our allies.

One investment counselor told M/R: "You'd see more if it were not political suicide to ask for it."

Among other recent indicators of new thinking affecting investment in defense-oriented issues, one of the most telling has been the article by Roswell Gilpatric published in this month's issue of *Foreign Affairs*. In it the just-retired Deputy Secretary of Defense estimates that the U.S. defense budget could be cut by 25% by Fiscal Year 1970 without a disarmament. This assessment is viewed by many observers as a trial balloon, testing out the acceptance of what well may be the current long-term thinking in the Pentagon.

The debate over disarmament and what it would do to the health of the U.S. economy appears to aid and abet Soviet propaganda. However, many analysts point out that they are not advising against disarmament, only stating that they don't feel that the current world situation indicates disarmament is likely.

Even in the event of disarmament, some experts believe, considerable new business would be generated in the arms control industry which would spring up to support any agreement. They add that any understanding that might be reached would be a slow, evolutionary process taking several years, affecting obsolescent systems first, and allowing for readjustment into an expanding commercial economy.

• **Complications**—Evaluating the aerospace business as an industry, and companies as individual investments divorced from the group, has evolved into a very complex task. It calls for studying highly technical companies, their management, accounting procedures, government attitudes, politics, and international situations. Hence, the decision to buy, even at low prices and relatively high yields, is still one which requires considerable investor confidence.

An investor looking for budget projections for 1970 can latch on to any figures he wants, ranging from Gilpatric's estimate of something under $40 billion for defense to the DL&J estimate of over $70 billion, including both defense and space expenditures. The space expenditures are judged to be highly significant in reaching any total. Most analysts feel that the NASA budget will stay at least in the neighborhood of its current $5-billion annual level and may increase under the Johnson Administration. There is also widespread feeling that "within five years military space spending will explode."

- **Some plus factors**—Though defense issues have always posed problems, and no doubt will continue to sell at reduced P/E multiples, there are factors which are now working in their favor.

One such factor is the impact of the widely publicized programs of Defense Secretary McNamara. Prominent are moves towards more incentive and fixed-price contracts, rather than the earlier cost-plus-fixed-fee types. In addition, there are several other projects aimed at improving company profits—by every means from lessening the threat of renegotiation to reducing the danger of having major programs cancelled even after they have passed an extensive program-definition phase. Though these steps take effect slowly, results are already encouraging. A second factor is the widespread view that projected near-term cuts in defense budgets will remain largely in areas which do not affect the aerospace industry.

Thirdly, defense and space issues have shown a marked counter-business-cycle trend which acts as a hedge against a general recession. This was apparent after the severe May, 1962, market drop, when serious questions were raised as to the health of the broad-based U.S. economy.

Most commercial issues dropped sharply. The aerospace group, however, turned in a superior performance for several months—precisely because its support was relatively independent of general economic considerations. After the Cuban missile crisis, when it became clear that the economy was stronger than had been thought, there was fresh interest in price-depressed industrials—at the temporary expense of the aerospace issues.

There is also a tendency now for reduced return on investment for aerospace contractors, reflecting less dependency upon government-furnished equipment. While this has hurt somewhat, DL&J notes that "it places contract negotiators in a stronger position than ever before to justify higher fees on new projects which use more contractor-furnished facilities."

- **Signs of stability**—In contrast with the budgetary events of 1963, which created an environment for further stock price slippage, indications so far this year are that NASA's Fiscal Year 1965 request for $5.3 billion will get through Congress with only minor cuts, as will the total DOD FY '65 spending estimate of $51.2 billion.

Though the defense outlay has been trimmed about $1 billion below last year, and may undergo some further small cuts in Congress, the bill has made it quite clear to many investors that enormous sums are still being spent in this business and that many company backlogs will remain high. Also in this quarter, the Air Force's Lockheed A-11 was revealed, the Supersonic Transport program came to a head, and the shooting down of two U.S. planes over East Germany came as a warning against overestimating the thaw in East-West relations.

Finally, the risks of buying missile/space issues are now moderate, say many counselors, because the stocks sell at moderately low price/earnings ratios and, in many cases, at good yields—on the order of 5% or better. Major aerospace issues now sell generally at between 9-11 times earnings, compared with about twice that figure for the industrial average. Some of the "glamor" electronic stocks sell for 30-60 times earnings.

- **New name needed?**—In addition to the familiar arguments against buying these issues, other factors appear to be harming the "Aerospace group"—unjustly, in the view of some advisers.

For one thing, some analysts feel that the group of stocks which make up the "Group" ought to be widened, or the term dropped. Some counselors already refer to a "National Survival Industry" in reference to the broadly-based U.S. defense and space business.

In a speech before the New York Society of Security Analysts, Stuart H. Clement, Jr., of Hayden, Stone & Co., Inc., said: "I don't believe the aerospace industry is falling apart. Rather it seems to be melding itself into the fabric of our economy so that some of it is becoming unrecognizable. Perhaps it would be better appreciated under a new name."

Nine firms—Boeing, Douglas, General Dynamics, Curtiss-Wright, Lockheed, Martin, North American, Republic, and United Aircraft—make up the Standard & Poor Aerospace Group. The Merrill Lynch "Group" includes those nine plus Avco, Grumman, Ling-Temco-Vought, McDonnell, Northrop, Thiokol, Thompson Ramo Wooldridge, and Sundstrand.

These firms obviously represent a large chunk of the aerospace business, but there are many other firms, companies—particularly in electronics—which are awarded billions in defense dollars each year and are almost as heavily committed to the single customer as some of the airframe primes. These, however, bear very little of the stigma which is focused upon the traditional primes during periods of uncertainty. Says one analyst: "If Grumman Aircraft were named Grumman Electronics it would be selling at 100 (Grumman's current market price is about $42 a share)."

"The chartists have doomed us," another says. "They serve a function, but they treat all horses alike."

What happens, he continues, is that those that are easily identified with the aerospace industry "suffer perhaps more than they should. They also have a tough time in comparison with what is now the competition, because in many cases the competition is not one of their traditional enemies."

- **Indiscrimination**—This grouping of companies has worked against the industry in other ways. For example, many advisers point out, there is very little intelligent discrimination on the part of investors between companies making up the group. This reflects a lack of knowledge of an industry which actually is an open book in comparison to virtually all others.

Basically, there is still a cliché-type reaction to the major airframe contractors which works to the advantage of the poorer-managed companies.

Aerospace contractors trying to diversify into the commercial sector thus far have not produced any compelling new reasons why investors should seek them out. One of the ironies of the depression in prices associated with defense stocks is that in many cases the major losses incurred have resulted from participation in commercial transport production.

In a New York speech earlier this year, James S. McDonnell, chairman of the board of McDonnell Aircraft Corp, said: "Based on 25 years of experience in our company, I can guarantee that it is almost impossible to create sufficiently worthwhile and profitable commercial products at industrial plants developed to successfully meet the needs of complex government procurement." Most analysts agree with McDonnell, whose firm usually is listed along with North American, Grumman, Lockheed and Boeing as among the currently most attractive aerospace issues.

One market researcher told M/R he believed that many of the prime defense contractors had "bitter experience in the non-aerospace business, in addition to poor experience as a non-prime." By the same token, he said, the experience of many commercially oriented firms with footholds in the defense business has been unprofitable.

Despite all this, the technical potential of the industry is so great that it not only compels companies to continue in it, but continues to attract participation by new, heavily commercial firms. ■

An M/R exclusive . . .

Hornig Outlines U.S. Space Mandate

President's new science adviser sees space program at least level-funded into 70's; describes his recommendation process

M/R photo

Dr. Donald F. Hornig became Special Assistant to the President for Science and Technology on Jan. 24. He also is Chairman of the Federal Council for Science and Technology, Director of the Office of Science and Technology in the Executive Office of the President, and Chairman of the President's Science Advisory Committee.

Author of about 70 scientific papers in the field of chemistry, Dr. Hornig was the first incumbent of the Donner Chair of Science, established in 1958 at Princeton University. He has taken part in many policy-making government committees and in 1962-63 was a member of the delegation which negotiated the agreement with the USSR for cooperation in space.

THE UNITED STATES does not need Soviet competition to prime the American space pump. The U.S. clearly has a mandate to explore space and will live up to it.

To do this, the nation has erected a national space program, not the exclusive property either of the National Aeronautics and Space Administration or of the Department of Defense.

The U.S. space program probably will go into the 1970's at least with the funding it has today.

These are a few of the opinions of Dr. Donald F. Hornig, Special Assistant to the President for Science and Technology, given in an exclusive interview with MISSILES AND ROCKETS.

Speaking of the nuclear powerplant SNAP 10A, Hornig says there is no "requirement that you have a requirement" from a user in order to carry a major program forward, but he warns against carrying every major program to completion. "This would be the most potent argument I know of for not starting things at all."

This interview with Dr. Hornig was conducted by M/R Senior Editor William Beller.

Question: *Dr. Hornig, if there were no space race with the Soviets, would you still recommend that the national space program be maintained at the level it is today?*

Answer: Yes. It's clear that space is a major factor in our world. It's inconceivable that when a nation is capable of doing something about exploring space and learning more about it we would just sit back and do nothing.

Q: *How do you see our role in space interacting with the country's overall activities in science and technology?*

A: When anything brand new begins to unfold, its subsequent history depends on what happens as it goes along, not just on the initial plan or attitude. Success breeds success in most fields. Thus, what happens to the U.S. space effort relative to other technical efforts depends on what opportunities the country sees for itself as the space program progresses.

These opportunities will follow from successes in space and from the involvement of industry in what it develops.

Q: *How do you think our space program is progressing?*

A: Magnificently! There are problems, everyone knows that. But in the years since 1957, we've been given an understanding we never had before of the near-space environment and of Earth. There's a whole new set of ideas and feelings, not only among scientists, but also in the lay public about the space around us: Van Allen belts, magnetospheres, solar winds and so forth. I think these are measures of what we've learned.

In addition, we already have practical applications of space in the form of operational satellite systems, such as *Tiros* for weather, and we're one step away from a satellite communications system.

I don't see how anyone could feel other than there has been a very rapid and demonstrable progress. On the other hand, some of the very biggest things on which we've set our sights are still around the corner. I see no reason to believe we are anywhere near the end of the road in space.

Q: *On that basis, then, it would seem in the country's best interests to look forward to a national space program at least level-funded and possibly increasing over the years. Is that right?*

A: In a general way, I'd say yes. The current budget, as you know, is almost exactly the same as last year's. It's unavoidable, though, that anything as expensive as space will bring up the question of trade-offs. It's not only how enthusiastic one is about space, but what the total picture looks like. What are the other demands on the country's resources? Everybody must appreciate the fact that the nation's space programs are sensitive to the state of the international situation and to the domestic economy itself. I don't know how to make any precise predictions about several years hence.

Q: *Turning to a specific space program, what is our national space effort going to be after Apollo? We know that as the lunar landing comes closer, Apollo spending will drop sharply. Is there a plan to continue our space efforts with other major goals, such as lunar exploration or Mars flybys and landings?*

A: There are clearly a series of successively more difficult scientific objectives which we will pursue with unmanned spacecraft. It's very difficult, though, to document a convincing case for a national commitment on major space goals that are far in the future. In any case, I can't believe that the momentum gained by our space program is going to be allowed to be lost when we achieve the first major objective.

Q: *You have to make many value decisions. How do you decide, for instance, whether to recommend support be given to building linear accelerators or to developing a Mars probe?*

A: There is no simple or arbitrary mechanism by which such recommendations can be made. It is not merely a matter of trading one program against another. Many factors must be considered in addition to scientific and technical considerations. One must consider the economic factors, among others.

Q: *To get more specific, suppose that at some time in the future, it were suggested that the U.S. establish a semipermanent lunar base. What factors would you consider before making your recommendations to the President?*

A: I'd first want to understand, as thoroughly as possible, what the function of the base would be. That is, I'd like to know realistically what we could expect to get out of it. And I'd like to get some clear idea of the costs involved and the place of the lunar base in a longer-run program.

That is where we'd have to start. Those are the factors we could pin down reasonably well and they would form a hard floor to stand on to talk about other factors. I want to emphasize that our primary responsibility is to see that the technical considerations are as solid as they can be.

Q: *The Air Force has the Manned Orbiting Laboratory project. It could as easily have been given to NASA. How does one decide which agency should get it?*

A: Our policy is to have a national space program and not separate DOD and NASA programs. In this case, one is aware that NASA, at the moment, is very much occupied in the *Apollo* program—and one would simply say that *MOL* seems more appropriate in DOD.

Certainly either agency has the facilities, interest and needs to pursue *MOL*. However, at the present time, these characteristics are more applicable to DOD.

Q: *Where space goals parallel one another, won't there be instances of duplication of effort. If so, is this a desirable situation?*

A: It certainly is not desirable. I know, though, that scientists and engineers can work on projects that have the same name, but are approached far differently. It's often very fruitful, in fact, to carry on parallel investigations just because the points of view are different. But if there is really overt duplication in developing the same thing, in a literal sense, then this is just sheer waste, an extravagance. If one found it, I think one should say that a choice of projects would have to be made.

Q: *Recent hearings on the Hill have pointed up the problem of government agencies being stymied in completing major projects because of the lack of a requirement from a prospective user. SNAP-10A is an example of this situation, where the AEC fears to go into a flight test with its nuclear powerplant because neither DOD nor NASA has said they want the device. Could this be an uneconomical procedure, as well as one that kills initiative?*

A: I don't think there's any requirement that you have a requirement. This just depends on what you're doing. If one's talking about a specific development with a specific rather than a general application, then I think the word "requirement" begins to come in with its full force.

A point that seems obvious to me is that if one's going to do creative, imaginative things, this involves risk. It means that you must anticipate from the beginning that there are things you are going to start that are going to have to be stopped. To go full circle, I think that the greatest block to starting new things would be to apply the argument that every time we've got an investment up to a point, we've got to see it through. To repeat, this would provide the most potent argument I know of for not starting things at all.

With respect to SNAP-10A, I think the question really is in what ways does the device have to be tested; what kind of tests would give prospective users the confidence to incorporate it into a system?

Q: *Would simply the need to advance the state of the art be a sufficient requirement for more work on a system, such as SNAP-10A.*

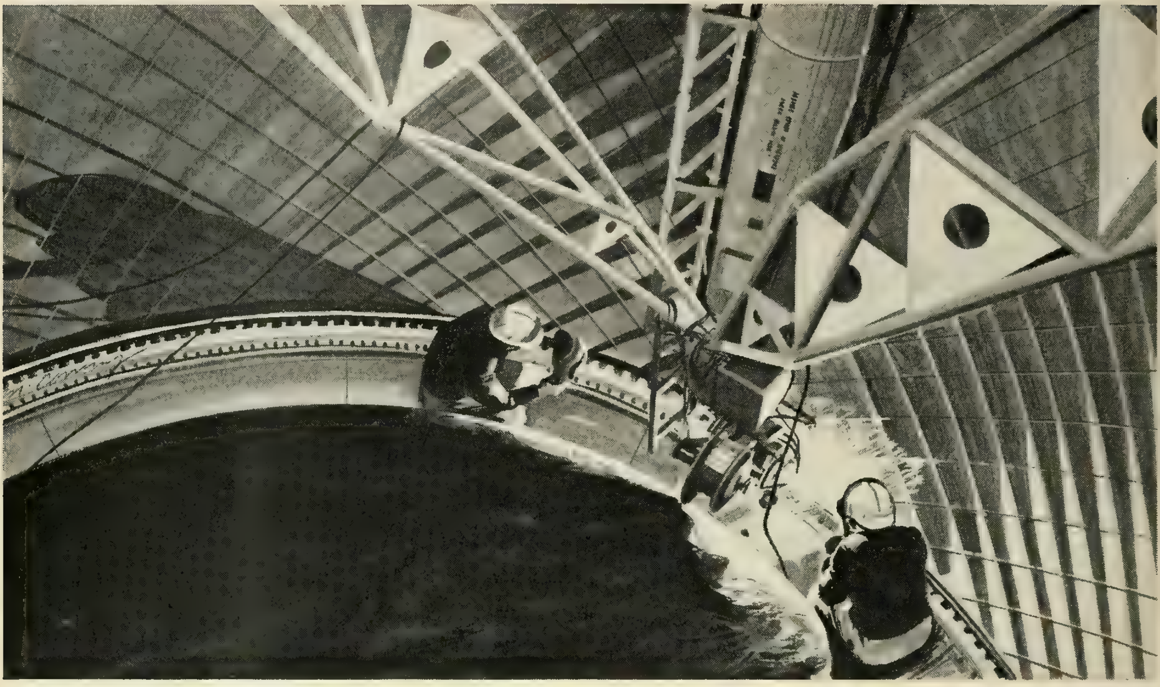
A: It certainly is, up to a point. The difficult question always is: where is that point? The question can be answered philosophically: the point is where the new technology has reached a stage where it is available to people who want to use it. This is the stage where SNAP-10A is right now.

Q: *During recent hearings, industry was asked what role it saw for itself if defense and space money were cut back. Are you giving much thought to this question?*

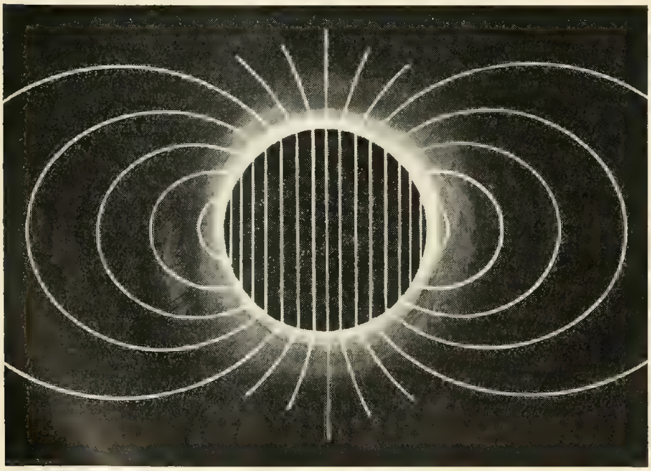
A: We're giving a lot of thought to it. As you know, for example, the President has set up a committee to consider the economic impact of disarmament. Certainly our country can't live without its industries and the skills that are embodied in them. But the thing I've been trying to stay away from is any notion that one ought to run a sort of WPA for flagging companies. We think it is not only wrong, but totally unnecessary.

There are many non-defense paths open to contractors presently in defense work. We still haven't nearly enough of the services our population requires. We still have a fifth of our population impoverished. There's so much to be done. It's a question of applying our ingenuity and skills to some of the problems that need solving. There's the question of economically getting fresh water from sea water—a mammoth problem. There are major problems of decreasing air and water pollution. Our office certainly wants to see capable industry drawn into studying solutions to major R&D problems such as these. ■

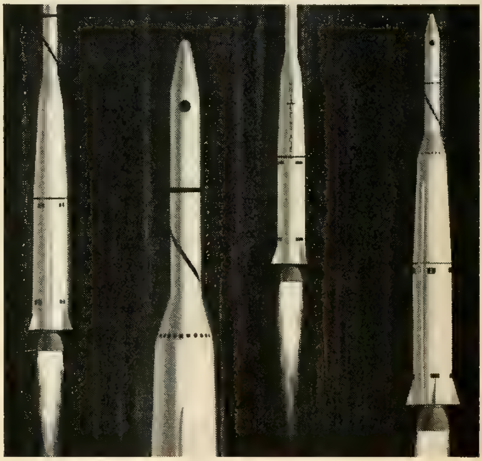
LOOK WHAT DOUGLAS IS DOING NOW!



FINAL ASSEMBLY OF MAMMOTH SPACECRAFT takes place in this huge tooling tower complex at the Douglas Space Systems Center in Huntington Beach, California. Here, provision is made for assembly, hydrostatic testing and checkout of giant space systems. The building includes 4,920 square feet of specially built insulation chambers.



WINDOWS IN THE EARTH'S MAGNETIC FIELD exist at the poles allowing solar and galactic cosmic radiation to penetrate to the vicinity of the Earth. Douglas maintains geophysical observatories in the Northern and Southern polar regions to record the effects of this radiation as it relates to space exploration and basic scientific knowledge. This program is jointly sponsored by Douglas and the National Science Foundation.



DOUGLAS-BUILT DELTAS have launched a majority of all Free World scientific and research satellites. Developed under the direction of the National Aeronautics and Space Administration, this three-stage space booster has achieved 22 consecutive successes. *Delta* is now also available in a new thrust-augmented version (TAD).

DOUGLAS

MISSILE & SPACE SYSTEMS DIVISION

New Activities

TRW Space Technology Laboratories' Electronics Div., Redondo Beach, Calif., has formed a department to design and produce advanced thin-film solid-state and hybrid integrated devices. The new department will be part of the newly enlarged Product Engineering and Microtechniques Laboratory. Move is to extend STL's capabilities in microelectronics. . . . *Joseph T. Ryerson & Son, Inc., Chicago, has entered the missile/space metals field and is now taking orders for tungsten, tantalum, molybdenum, columbium, hafnium, titanium and zirconium and their alloys.* . . . The Sperry Rand Corp. has established a systems research group at its Research Center in Sudbury, Mass. The group is to conduct investigations into "learning machines," detection, measurement and control systems, and into areas of mathematics and experimental psychology applicable to systems. . . . *Sylvania Electric's Applied Research Laboratory, Waltham, Mass., has formed two new departments, one for research in laser technology, the other in automatic controls. Names of the new departments are Electro-Optical Research and Automatic Control.* . . . The Budd Co. has combined its Advanced Development and Planning Center, Arlington, Va., and its Technical Center, McLean, Va., into a separate organization to be known as the Budd Information Center. Both units will retain their identity within the new organization. . . . *Thiokol Chemical Corp. is making its Space Booster Plant in southeast Georgia a division effective May 1. Thiokol's Alpha Div. is being dissolved in the organizational change. Both the Space Booster Plant and the Huntsville Plant, Huntsville, Ala., which now answer to the Alpha Div., will become divisional entities at that time.*

Aerojet Plants Re-Aligned

Aerojet-General Corp. has consolidated its Solid Rocket and Liquid Rocket Plants, both at Sacramento, Calif., and its Rocket Engine Operations-Nuclear, presently at A-G's Von Karman Center, Azusa, Calif., into one plant at Sacramento. The move is aimed at "greater efficiency and stability for long-range business planning."

Mergers and Acquisitions

The Fluorocarbon Co., Anaheim, Calif., has purchased the Santa Clara, Calif., plant of Saunders Engineering Co. Both Fluorocarbon and Saunders are processors and fabricators of fluorocarbon plastics. . . . *Jetronics, a subsidiary of Jetronic Industries, Inc., Philadelphia, has purchased the ultrasonic stock, equipment designs, engineering designs, engineering files and materials of the Curtisonic Div. of the Curtiss-Wright Corp.* . . . Duncan Electronics, Inc., Costa Mesa, Calif., has acquired the assets of Electronic Micromolding Co., Santa Monica, Calif., manufacturer of slip-ring and brush assemblies and miniature moldings for the electronics industry. Duncan makes precision potentiometers and accessories for missile/space and aircraft applications. . . . *Dubrow Electronic Industries, Inc., stockholders have approved a merger of the company with Teledyne, Inc., Hawthorne, Calif. Dubrow, located in Burlington, N.J., is to become a division of Teledyne.* . . . The Fafnir Bearing Co., New Britain, Conn., has formed an Aerospace Sales Div. to serve the missile/space and aircraft industries. The new division will be concerned with ball bearing applications in the space, missile, aircraft and instrument fields, with the exception of aircraft generators.

New Facilities

Vitro Corp. of America, Silver Spring, Md., has announced that its Vitro Laboratories Div. has opened a new project office in Huntsville, Ala. The division joins sister activities, Vitro Services and Vitro Engineering Co., at Huntsville. . . . *Anadex Instruments, Inc., Van Nuys, Calif., manufacturers of analog and digital equipment, has expanded its facilities in a move to 7833 Haskell Ave., Van Nuys. The new facility will house executive offices, sales display room, engineering and drafting departments and all production facilities.* . . . General Aerospace Materials Co., Inc., Beth Page, N.Y., has opened a new 10,000-sq.-ft. facility in Wichita, Kans. The facility will include warehouse, office and shipping space, which, with the firm's Dallas operation, will service the western and mid-western states previously served by Dallas alone. . . . *Severna Manufacturing Corp., East Orange, N.J., has doubled facilities for production of fluorocarbon plastic parts for electronic, chemical processing and cryogenic equipment.* . . . Amphenol-Borg Electronics Corp. is enlarging its ceramic facilities by establishing a pilot plant to produce precision-molded ceramic parts for electronic and electrical components. The operation will be located in the Company's Broadview, Ill., plant, and is expected to be in production by June 30. Included in the products to be manufactured are precision-moldable ceramic substrates for thin-film and integrated circuitry and moldable ceramic inserts for high-temperature connectors. . . . *American Air Filter Co., Louisville, Ky., has opened a branch office in Philadelphia to service the area formerly covered by Hucker Sales Co. AAF makes missile/space and aircraft environmental control systems and components.* . . . Valley Metallurgical Processing Co., Inc., Essex, Conn., has opened a new plant in Stockton, Calif. VMP produces fine-grade spherical powdered aluminum used in solid-fuel propellants.

GD Unit Wins Safety Award

General Dynamics/Pomona, Pomona, Calif., has been awarded first place in the 15th annual Los Angeles safety contest. GD/P's accident rate for 1963 was 0.78 per million, compared to the aerospace industry's average rate in the Los Angeles area of 1.46. Seven hundred and twenty-six companies in all phases of business competed in the contest.

contracts and procurements

Awards

AIR FORCE

$6,100,000—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for continued provision of launch services for *Agena D* boosters at the Pacific Missile Range.

$4,393,000—**Westinghouse Electric Corp.,** Baltimore, for installation and testing of radar sets at Air Force installations in the United States and Canada.

$3,027,852—**TRW Space Technology Laboratories,** Redondo Beach, Calif., for engineering support of Air Force ballistic missile programs.

$2,300,000—**McDonnell Aircraft Corp.,** St. Louis, for continued work on space-associated projects.

$1,900,000—**Ralph M. Parsons Co.,** Los Angeles, for work at various *Titan II* missile sites.

$1,800,000—**TRW Space Technology Laboratories,** Redondo Beach, Calif., for follow-on engineering related to various ballistic missile programs.

$1,500,000—**Dow Chemical Corp.,** Midland, Mich., for continued development of solid fuel propellants.

$1,200,000—**Adler Electronics, Inc.,** New Rochelle, N.Y., for continued manufacture of communications vans.

$1,200,000—**General Dynamics Corp.,** Astronautics Div., San Diego, Calif., for continued work on *Atlas* missiles.

$750,000—**Cubic Corp.,** San Diego, Calif., for the manufacture of two tracking systems for the Pacific Missile Range.

$525,557—**D. B. Milliken Co.,** Arcadia, Calif., for high-speed 16-mm motion-picture cameras and equipment to be used in recording missile firings at Vandenberg AFB, Calif.

$496,000—**Northrop Corp.,** Ventura Div., Newbury Park, Calif., for development of a parachute capable of controlled glide to an exact landing point, to be used in maneuvering space vehicles.

$144,000—**Arinc Research Corp.,** Washington, D.C., for two programs: one, a study to expand reliability prediction by function techniques to airborne electronic equipment; and, two for engineering services to correct deficiencies and improve reliability of a height-finder radar system.

$44,018—**Dynamic Science,** South Pasadena, Calif., for propellant sprays in liquid rocket engines.

$40,600—**Atlantic Research Corp.,** Alexandria, Va., for research on hydrogen-fluorine reaction.

United Technology Center, Sunnyvale Calif., for demonstration of an advanced solid propellant with a metal additive (amount undisclosed).

Kollsman Instrument Corp., Space Div., Elmhurst, N.Y., for analytical investigation, experimental testing and specification of models of space-navigation-data-acquisition and data-processing equipment (amount undisclosed).

ARMY

$4,759,284—**General Dynamics,** Pomona, Calif., for continued research and development of the *Redeye* guided missile system.

$3,300,000—**Sylvania Electric Products, Inc.,** Mountain View, Calif., for R&D in the electronic warfare field.

$1,000,000—**Raytheon Co.,** Lexington, Mass., for follow-on development work related to the *Hawk* air defense system.

$115,700—**George T. Sparrow,** Maitland Fla., for construction of an addition to the communications building at Patrick AFB, Fla.

The Garrett Corp., AiResearch Manufacturing Div., Los Angeles, for development of an X-band microwave amplifier integrated with a cryogenic refrigeration system suitable for mounting on a microwave antenna (amount undisclosed).

NAVY

$17,743,500—**Bendix Corp.,** Mishawaka Ind., for production of *Talos* air defense missiles.

$9,500,000—**Raytheon Co.,** Waltham, Mass., for missile guidance systems for F-4B and F-4C aircraft.

$1,061,473—**American Machine & Foundry Co.,** York, Pa., for antisubmarine rockets.

NASA

$1,340,000—**Greer Hydraulics Inc.,** Aerospace Div., Los Angeles, for hydraulic supply units for Marshall Space Flight Center.

$570,841—**Graduate Research Center of the Southwest,** Dallas, for a cosmic radiation experiment for the *Pioneer* spacecraft.

$490,681—**Marshall Laboratories,** Torrance, Calif., for plasma probe experiments for the *Pioneer* program.

$145,171—**Aircraft Armaments Inc.,** Cockeysville, Md., for payload housing for a Wasp fluid dynamic experiment.

$71,434—**The Hallicrafters Co.,** Chicago, for a follow-on study of communications systems and detection and tracking systems, and design and fabrication of dynamic crossed-field electron multiplying light demodulator.

$66,000—**Applied Research, Inc.,** Port Washington, N.Y. for four RF amplifier/converters.

$58,622—**General Electric Co.,** Missile & Space Div., Valley Forge, Pa., for thermal bending of gravity gradient rods.

$55,000—**Avco Corp.,** Willmington, Mass., for grating spectrometers for spacecraft applications.

$46,700—**American Scientific Corp.,** Alexandria, Va., for services and materials for PCM tape evaluators.

$41,228—**Boller & Chivens Inc.,** South Pasadena, Calif., for a telescope and associated equipment.

$32,800—**Merle Thomas Corp.,** Washington, D.C., for programming in support of environmental testing of *OAO* experiment packages.

$25,213—**Armoux Corp.,** Culver City, Calif., for telemetering decommutation systems.

California Computer Products Inc., Los Angeles, for design and development of a ground-based data code printer which will accept data from *Nimbus* satellites (amount undisclosed).

INDUSTRY

$22,000,000—**Radio Corp. of America,** New York, from **Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for the communications subsystem of the *Apollo* Lunar Excursion Module.

$2,700,000—**Catalytic Construction Co.,** Philadelphia, from **The Boeing Co.,** Seattle, for miscellaneous construction and installation of portions of the *Minuteman* weapon system support equipment at Warren AFB, Wyoming.

$1,200,000—**American Brake Shoe Co.,** Aerospace Div., Oxnard, Calif., from **North American Aviation, Inc.,** Space Information Systems Div., Downey, Calif., for hydraulic pumps and pump-motor packages for the *Saturn V* second stage booster.

$1,046,000—**Bendix Corp.,** Pioneer-Central Div., Davenport, Ia., from **The Boeing Co.,** Seattle, for *Saturn V* S-1C propellant instrumentation.

$1,000,000—**Hydraulic Research and Manufacturing Co.,** Burbank, Calif., from **Lockheed Missiles & Space Co.,** Sunnyvale Calif., for steering actuators for the *Polaris A-3* missile.

$495,000—**Gulton Industries, Inc.,** Metuchen, N.J, from **North American Aviation, Inc.,** Space & Information Systems Div., Downey, Calif., for the design, development and manufacture of a data reduction system for the *Saturn V* S-II second stage.

$212,000—**United Electrodynamics, Inc.,** Pomona, Calif., from **The Boeing Co.,** Seattle for telemetry equipment for the *Minuteman* missile program.

$55,000—**Chem-Electro Research, Inc.,** Van Nuys, Calif., from **TRW Space Technology Laboratories,** Redondo Beach, Calif., for production of high-reliability ceramic capacitors.

NATIONAL RESEARCH COUNCIL

$2,535,000—**Varian Associates,** Palo Alto, Calif., for construction of a 200-ft.-long linear accelerator to be installed near Rome, Italy, for the Italian Atomic Energy Commission's National Frascati Laboratories.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California 94035

Ducts, cruise fan type, for 36-in. tip-turbine fans, 2 each. RFP A-8087 due 4/20/64.

National Aeronautics and Space Administration
Manned Spacecraft Center
2101 Webster-Seabrook Road
Houston, Texas 77058

Pressure transducers, lightweight, high-output flight items, 12 each. RFP MSC 64-1153P. Due 5/1/64.

Directorate of R&D Procurement
Systems Engineering Group, RTD
Wright-Patterson AFB, Ohio

Negotiations will be conducted with The Boeing Co., Seattle, for continuation of research studies of the *X-20* program. A continuation of AF 33(657)-7132. For information only. RFP 5842-KNA not available.

National Aeronautics and Space Administration
Manned Spacecraft Center
2101 Webster-Seabrook Road
Houston, Texas 77058

Negotiations will be conducted with Avco Corp., Tulsa, Okla., for study of an investigation of the optical degradation of glasses exposed to the radiation environment of space. RFP MSC 64-1163P not available. For information only.

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Va. 23365

Heat source, high-intensity radiant energy in accordance with NASA specifications. One lot. IFB L-4463. Bid opening 5/4/64.

National Aeronautics and Space Administration
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Furnish and deliver vacuum booster pump with drive motor, in accordance with NASA Lewis Research Center Specifications. Deliver within 90 days after date of reward. Copies of IFB C-150759 will be furnished to the extent available on first-received, first-served basis. Bid opening 5/14/64.

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

Request for a system of two antenna assemblies and associated solid-state servo controls for a mobile tracking system. PCN 68611. This is a two-step procurement. Deadline is 5/13/64.

HONEYWELL

INSTRUMENTATION NEWS

MILITARY EDITION

Number 2-MI

Honeywell Designs Custom Cryostats

POTTSTOWN, Pa. — Cryostats designed by Honeywell's Special Systems Division for the calibration of platinum and germanium cryogenic temperature sensors are now in service at NASA's Huntsville, Ala., facilities in connection with the Saturn space vehicle program.

The self-contained, integrated systems include dewars, precision control equipment, high-accuracy measuring circuits and digital readout equipment. Also in the relay rack-mounted systems are programmers for automatic operation and NBS calibration reference standards.

Calibration is accomplished by inserting test and control sensors and the primary standard into the appropriate cryogen — liquid helium, nitrogen, hydrogen, etc. By controlling the temperature of the cryogen at various levels, defined precisely by the primary standard, calibration data is developed and printed out. Up to six sensors of the same type can be calibrated at one time.

All Honeywell cryostats are custom-designed. Inquiries should include such information as calibration range, sensor type, sensor size, number to be calibrated at one time, accuracy requirements, and typical calibration curves.

WRITE FOR FULL INFORMATION

New Portable Lab Recorder Measures 100μv to 100v

PHILADELPHIA—Honeywell's Philadelphia Division recently introduced an all new portable lab recorder capable of measuring voltages from 100 microvolts full scale to 100 volts dc full scale without auxiliary equipment.

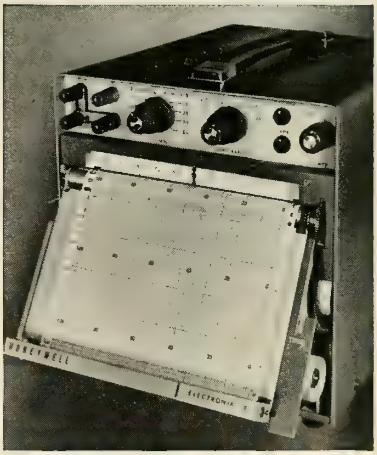
This new instrument, the *ElectroniK 19* strip chart recorder, combines a wide measuring range with a variety of features which its designers say makes it one of the most versatile recorders available for laboratory or test applications.

In introducing the new instrument, Honeywell Market Manager William Forsyth emphasized that the *ElectroniK 19* recorder has been designed specifically to meet the needs of the military test market.

"For example," he explained, "the wide selection range of the new instrument makes it possible to measure with one recorder signals which usually require several units or auxiliaries such as preamplifiers or attenuators."

The *ElectroniK 19* lab recorder has a unique tilting platen that pulls up from a vertical position and locks at either a 30° or 45° angle.

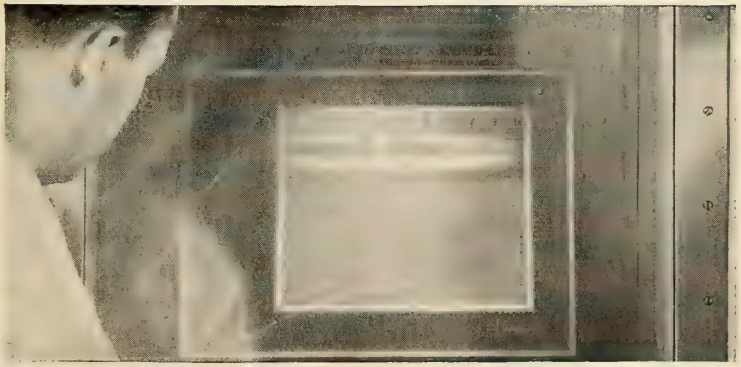
"There also is a tear-off bar for fast, easy removal of selected records," Forsyth pointed out. "When you add the completely removable chart transport and quick thumb-wheel selection of 10 chart speeds from one inch in 10 minutes to an inch a second, you can appreciate how we have engineered this instrument for the user."



ELECTRONIK 19 **PORTABLE LAB RECORDER has a range from 100 microvolts to 100 volts full-scale, weighs less than 20 pounds, occupies less than one square foot.**

Forsyth also noted that the new recorder's potentiometric measuring circuit provides ±0.25 per cent full-scale accuracy and up to 100 per cent of full-scale zero displacement to expand the effective range when the signal goes off scale. Other standard features include high-performance, null-balance servo with frequency response down less than 1% full scale at 5 cps from 10% peak-to-peak amplitude, along with wide measuring capacity from low-impedance detectors to high-impedance bridges.

WRITE FOR FULL INFORMATION



NEW *ELECTRONIK 16* Strip Chart Potentiometer is subjected to temperature and humidity extremes in a Honeywell evaluation laboratory environmental chamber. An intensive evaluation program for the *ElectroniK 16* line assures quality, overall reliability and repeatable performance capability under a wide range of operating conditions.

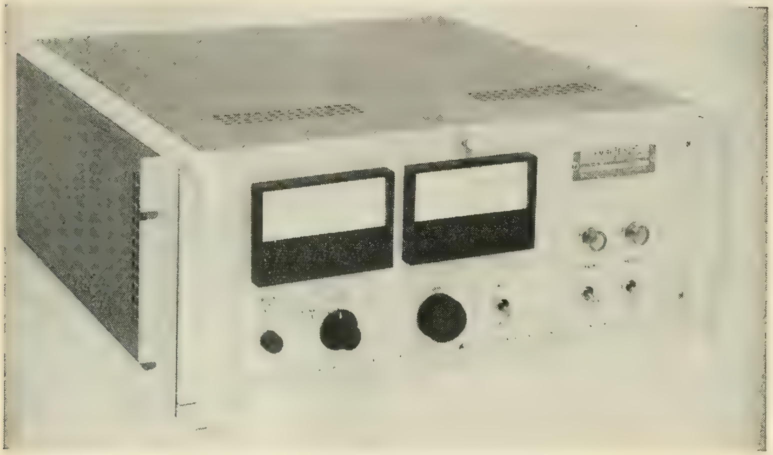
Honeywell

INDUSTRIAL PRODUCTS GROUP
PHILADELPHIA, PA. 19144

HONEYWELL INTERNATIONAL
Sales and service offices in principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

Circle No. 10 on Subscriber Service Card

New Product of the Week: Wideband FM Receivers



Wideband FM receivers incorporating baseband capabilities to 15 mc with low distortion are available in standard designs from RHG Electronics Laboratory, Inc.

Basic IF units at 60 and 160 mc, as well as complete microwave receivers in L-, S-, C- and X-bands can be supplied. Specifications for a typical model include an RF frequency of 860 mc; IF frequency of 60 mc; non-linearity of 3% maximum and a 10-db noise figure.

Circle No. 151 on Subscriber Service Card

Non-Burning Laminate

The Mica Corp. has introduced a non-burning G-11 type copper-clad laminate that can be dip soldered, and/or electroplated, and/or vapor degreased without detrimental effect.

The Micaply Grade EG-824-T utilizes a resin compound which allows it to retain at least 50% of its flexural strength after exposure for one hour at 300° F. When tested in accordance with ASTM D635, it exceeds the requirements of MIL-P-13949C.

Circle No. 152 on Subscriber Service Card

Speed Control Manifold

Fluid Power Div. of the Aurora Corp. has introduced an aluminum-bodied multipurpose speed control manifold for controlling air, oil and other fluids.

The unit has a control which will lock in any position assuring a constant flow at any position. It has a full ⅜-in. orifice and is adaptable to operating pressures from 0 to 2,000 psi. It is supplied for use as a manifold bolted to either side of the body, with ¼, ⅜ or ½-in. ports.

Circle No. 153 on Subscriber Service Card

Transistor Cooling Package

A transistor cooling package which requires ⅓ less space and eliminates thermal gradients between mounting stations is available from PinFin, Inc.

The unit electrically isolates each transistor heat sink, maintains low thermal resistances tailored to job requirements and can be mounted directly to standard 4⅛-in. bolt fans.

Standard models are available in 8, 10, 16 and 20 stations. Others are available on order.

Circle No. 154 on Subscriber Service Card

Slewing Switch Module

A five-position slewing switch module which provides manual control for bi-directional, two-speed re-zeroing in digital display packages is available from Technology Instrument Corp. of California.

The Model PVR09-K387 has a spring return for self-centering with two switch segments in each direction from the center null. One version is equipped with 0-rings which provide protection against high humidity environments and presets an 8 oz.-in. friction load at the manual control knob.

Three detents are incorporated, one at the center null and one each before passing from the two "intermediate" segments in either direction to the "high" speed switching segments. Two switching positions are incorporated on each side of null; the "intermediates" typically ±35°, and the "high" speeds typically ±70°.

Circle No. 155 on Subscriber Service Card

Coaxial Switch

Philco Corp.'s Lansdale Div. has introduced a solid-state coaxial switch capable of operation at any frequency within the VHF to X-band spectrum.

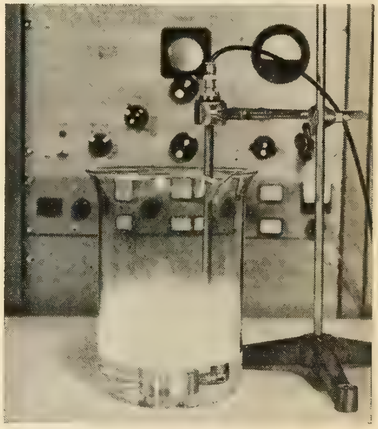
The Model PS9501, with its 25 to 7,500-mc range, has a typical switching speed of less than 10 nsec. Insertion loss is less than 1 db with an isolation greater than 25 db over a bandwidth of 100:1. Amplitude modulation is greater than 85%. With a 300:1 bandwidth, it has an insertion loss less than 4 db with an isolation greater than 15 db. Amplitude exceeds 50% at modulation rates to 1 mc.

Circle No. 156 on Subscriber Service Card

Immersible Transducer

The Macrosonics Corp. has introduced a 2-mc immersible transducer for continuous production of dense submicronic aerosols.

When immersed at proper height into a liquid, the Type A-2000 transducer creates a "dry" fog with uniform droplets smaller than 1 micron. Terminal velocity of these particles is 0.003 cm/sec. which corresponds to a settling rate of slightly more than 6 ft. per 24 hours. A small generator driving the input gives the possibility to produce between 75 and 250 cc of aerosol per hour when using liquid such as water and methanol.

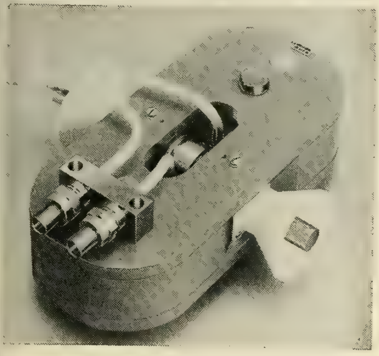


Circle No. 157 on Subscriber Service Card

Fixed-Frequency Magnetron

A fixed-frequency pulse magnetron in the millimeter wave range is available from Litton Industries' Electron Tube Div.

The L-3750 operates in a 34,500 to 35,200-mc frequency range with a minimum peak power of 100 kw. The liquid-cooled unit has a typical operation rated at a peak voltage of 20 kv and peak current of 25 amperes.



Applications include airborne mapping radar, weather detector radar and aircraft landing radar.

Circle No. 158 on Subscriber Service Card

Pressure Control System

A pressure calibration control system capable of testing pressure sensing devices up to 1,000 psi has been introduced by Trio-Tech, Inc.

The Model 367 contains a 0 to 10,000 psi inlet pressure gauge, a self-relieving pressure reducing regulator, a precision pressure regulator with a sensitivity adjustment of 0.0005 psi, a 16-in. heise gauge with an accuracy of 0.1 of 1% full scale and a rupture assembly for system protection.

Circle No. 159 on Subscriber Service Card

Electronic Commutator

NP Laboratories, Inc., is marketing a 90-channel electronic commutator of all-silicon circuitry and designed especially for airborne applications.

The Model ALL-90M features a back current of 0.05 microamp maximum at elevated temperatures. Common mode rejection is 100 db. Input impedance is 1 megohm. Scatter is 50 mv maximum referred to input. The device has an operating temperature range of —20° to 80° C.

Circle No. 160 on Subscriber Service Card

Tape Transport

A high-environment tape transport, the Model 10-110, is being marketed by Genisco Data, a division of Genisco Technology Corp.

The unit has been proved in the field at vibrations to 70 g's peak-to-peak, at 20-ms shocks of more than 100 g's and at accelerations in excess of 50 g's with little or no degradation of basic performance, the company says.

The system has an FM, direct or digital recording capability at tape speeds of 1⅞ to 120 ips in standard increments. Flutter is less than 1.0% peak-to-peak at 60 ips, dc to 1,000 cps. It has a capacity of 1,200 ft. of 1-mil tape.

Circle No. 161 on Subscriber Service Card

Flexible Strain Gauges

Information on internal strain and stress to 10% or greater (1/10 in./in.) in solid propellants and similar visco-elastic materials can be provided by a series of flexible strain gauges developed by Gulton Industries.

The three models have a volume of ⅛ cu. in. and utilize "Glennite" materials encased in primary rubber. The elements are so small, says the company, that there is practically no effect on the vibrational characteristics of the structure.

The FSG-2890 is a dynamic strain gauge with up to three mutually perpendicular measures, tension and compression. Frequency response is 20 to 600 cps with ±5% variation.

The FSG-3400 dc static gauge measures single dimensional strain with a sensitivity of 1 mv/mil input.

The FSG-3300 is a dc shear gauge which measures single dimensional axial or radial strain with a sensitivity of greater than 50 mv for a 1% shear input.

Circle No. 162 on Subscriber Service Card

Garnet Material

A garnet material whose saturation magnetization can be accurately controlled—permitting mass-production manufacture of electronic and microwave devices—has been developed by Microwave Chemicals Laboratory, Inc.

The material MCL-290TG, can be typically held within 15 gauss at levels of 290 gauss, allowing components designs at frequencies as low as 100 mc.

Dielectric constant of the material is 13.4; loss tangent at 4.4 gc is less than 0.0005 and linewidth is 40 oersteds.

Circle No. 163 on Subscriber Service Card

Delay/Gate Generator

Berkeley Nucleonics Co. has introduced a 10-mc delay and gate generator featuring a calibrated amplitude discriminator.

Input signals above the threshold of the discriminator produce output pulses

M/R

special report

INSTRUMENTATION, CONTROLS, AND DATA ACQUISITION SYSTEMS
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PHONE: ADams 2-3271

Circle No. 8 on Subscriber Service Card

with an adjustable width from 50 nsec to 10 millisecs and adjustable delay from 100 nsec to 10 millisecs.

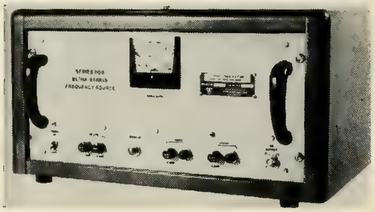
The Model CT-1 has a 10-mc repetition rate and an adjustable threshold from 0.1 to 11v. Accuracy is 1% of full scale; integral linearity is 0.5% Output specifications include a rise and fall time of 100 nsecs, 4v into 50 ohms.

Circle No. 164 on Subscriber Service Card

Frequency Sources

A line of frequency sources for critical applications at frequencies from 8 mc to 10 gc is available from Pitometer Log Corp.

The Series 1100 features short-term stabilities to one part in 10^9 and long-term (24 hours) stabilities to three parts in 10^8. Each frequency is obtained by selection of fundamental frequency crystal and varactor multiplier chain. Multiple output frequencies are also obtainable upon request.



Each series contains its own crystal oven, monitoring meter and optional power supply. Output is typically 1.0 watt at UHF, L- and S-band, 500 mw at C-band and 100 mw at X-band.

Circle No. 165 on Subscriber Service Card

Varactor Multipliers

A solid-state frequency multiplier which produces power outputs at 500, 1,000 and 2,000 mc is being marketed by LP Associates.

The Model 1000-1 varactor multiplier consists of three independent varactor frequency doublers which may be connected in series or used individually. With an input of 250 mc at 25 watts nominal, the unit provides output power in excess of 15 watts at 500 mc. At a frequency of 1,000 mc, output is 6 watts; at 2,000 mc, more than 2 watts output is available. At all frequencies, spurious frequency rejections exceeds 50 db.

Circle No. 166 on Subscriber Service Card

Instrumentation Amplifier

A differential dc instrument amplifier, said to achieve stabilization without a chopper, has been developed by Allegany Instrument Co., a division of Textron Electronics, Inc.

The Model 518 features a noise level of 3 mv to 10 kc and a 60-kc bandwidth. Linearity is 0.01%; common mode rejection is 120 db, and overload recovery is within 200 microseconds.

The solid-state device has a gain adjustable from 20 to 4,000. Output is ±10v at 100 ma.

Circle No. 167 on Subscriber Service Card

Infrared Tracking Sensor

An angular-error indicator, designated the Model 21-111 infrared tracking sensor, has been developed by Barnes Engineering Co.

The unit consists of an optical head and an electronics unit. The system receives infrared radiation emitted by its target and generates position error signals for transmission to a tracking servo system. Pointing accuracies of 0.02 to 0.05 milliradian have been achieved when the model is combined with standard positioning systems.

Circle No. 168 on Subscriber Service Card

Data Logging System

Kinelogic Corp. is marketing the KS-1 digital conversion-recording system, designed principally for meteorology and oceanography.

The unit provides sampling, digital conversion and recording functions and has an optional playback capability which permits periodic interrogation of the system through an RF link.

The system can sample 1, 4, 8 or 16 different inputs. Accuracy is ±0.5% with ±0.1% as an option.

Circle No. 169 on Subscriber Service Card

Liquid Sensor

An immersible optical-type liquid sensor which operates in all liquids without recalibration or adjustment is available from Bendix Corp.'s Pioneer Central Div.

The GT-103 senses presence or absence of liquid at a specific point with an accuracy of ±0.050 in. (typical) within a temperature range of —430° to 160° F. Response time in instantaneous. Power requirement is 28v dc. Output signal is dc voltage capable of driving meter or simplified transistorized switching amplifier.

Circle No. 170 on Subscriber Service Card

GOVERNMENT CONTRACTS—CYCLOPEDIC GUIDE TO LAW, ADMINISTRATION, PROCEDURE, John Cosgrove McBride and Isidore H. Wachtel, published by D.P. Indices, Inc., 205 E. 42 St., New York 17, N.Y., distributed by Matthew Bender & Co., Inc., San Francisco, multivolume looseleaf set.

Using this set is one of the easiest ways we know to become familiar with nearly any legal aspect of Government contracting. The books will be of great aid to attorneys working on Government contracts. We found, however, that it can be of even greater value to management people whose strength may be in technical fields, but who find themselves taking part in negotiation, fulfillment and interpretation of contracts.

Each chapter takes up a category of government contracting, gives general principles, then details, applications and case histories. We were happily surprised to find the text written simply and clearly, without legalistic jargon.

This set is the product of a long collaboration between two well-known attorneys: John McBride is Deputy Council at the Bureau of Supplies and Accounts, Department of Navy; Isidore Wachtel, a Washington attorney, has been representing industry for many years. Together, they brought half a century of experience into writing the cyclopedia.

A small extract from a section entitled Implied Contracts, which gives the flavor and authority of the books: "There is another type of agreement where the proposal or acceptance is conveyed not by words but by conduct. This is called an implied or tacit contract." The authors point out, "It would seem obvious that when an express contract completely covers the transaction between the parties, there is no need to imply anything more, *Remington-Rand, Inc. v. United States,* 128 Ct. Cl. 722 (1954). Consequently, an implied contract will arise only where something is missing in the form of proof, and this absence will be cured by the production of proof of conduct." This is continued with definitions of implied contracts and examples from cases at law. Topics include illegal government demands, lack of authority in government agent, government use of supplies and services, all told in 32 pages.

The authors' system will save legal researchers much time since the technique is to quote at length from landmark decisions of the courts, boards of contract appeals, the Attorney General and the Comptroller General. There is little need to go to the original source material. Time is also saved for the interested non-specialist since he does not have to accumulate or buy the material in this field. W.B.

SPACE LAW AND GOVERNMENT, Andrew G. Haley, Appleton-Century-Crofts, Division of Meredith Publishing Company, New York, 608 pp., $15.00.

"Space Law and Government" is an admirable addition to the literature on man's ventures into space. The volume treats a myriad of legal, sociological, and scientific topics.

There is an excellent analysis of the legal problems involved in space exploration; emphasis is placed on the fact that the authorities of the past, with their gaze fixed upon the earth, will not be of substantial assistance. In his discussion of technical matters, the author demonstrates an intimate familiarity with scientific details. His grasp of technical considerations is well illustrated by his analysis of the scientific facts that must be taken into account in establishing an upper boundary for national sovereignty. There is an extensive chapter on space communications, in which the author comprehensively but concisely discusses the uses of space telecommunications, the problems of frequency allocation, world-wide satellite communications, and orbital radio commands. There is a detailed section on space medical jurisprudence. The governmental and nongovernmental organizations throughout the world that are involved with space activities are described.

The author, Andrew G. Haley, has long been associated with space endeavors. During World War II, he was a co-founder, along with the late Dr. Theodore von Karman, of the Aerojet firm. The volume fulfills the promise expressed in the Foreword by Lyndon B. Johnson: "The distinguished background of the author and the painstaking research which has gone into this book point up the value of 'Space Law and Government.'" W.B.

ASTRONAUTICAL ENGINEERING AND SCIENCE—FROM PEENEMÜNDE TO PLANETARY SPACE, edited by Dr. Ernest Stuhlinger, Director, Research Projects Division; Frederick I. Ordway, III, Chief, Space Systems Information Branch; George C. Bucher, Scientific and Technical Assistant to the Director, Research Projects Division; and Jerry C. McCall, Assistant to the Director; all of the George C. Marshall Space Flight Center, National Aeronautics and Space Administration, Huntsville, Ala., 384 pages plus index. M. Hill; $17.50.

"Astronautical Engineering and Science," which was prepared to commemorate the 50th birthday of Dr. Wernher von Braun by a number of his former and present associates, is a complete account of the technologies and sciences forming the core of rocketry and space flight. Written by 38 experts in the field—many of whom participated in the events discussed—the book contains 18 chapters on rocket propulsion, rocket design, control and guidance, instrumentation and telemetry, space vehicle technology, space physics, launch operations, planetary exploration, and future projects. It reflects the various activities in which Dr. von Braun and his team have been engaged during the past 25 years.

Among the specific topics covered in the book are: the development of the *Saturn*; past, present, and future concepts for launching vehicles; tabular histories of launch vehicle firings; and the factors involved in making a launch vehicle suitable for manned space flights.

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names in the news

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William Milwitt: Joined the executive staff of Pulse Engineering, Inc., Santa Clara, Calif., as technical director.

Benjamin J. Trivelli: Appointed assistant chief engineer at Phelps Dodge Electronic Products Corp., North Haven, Conn.

Dr. Franklin W. Diederich: Named vice president-engineering at Avco Corp.'s Research and Advanced Development Div., Wilmington, Mass. **Dr. Murray E. Malin** named vice president-research and **Dr. M. Baron T. George** named vice president-plans and programs.

Charles E. Hunter: Appointed general manager of Thiokol Chemical Corp.'s Wasatch Div., Brigham City, Utah.

E. R. Skaggs: Elected vice president for engineering at United Control Corp., Redmond, Wash.

Ralph E. Costlow: Named military marketing sales representative in the east central states region for Motorola Semiconductor Products, Inc., Phoenix, Ariz.

Dr. Ernest J. Dieterich: Named director of engineering for the midwest operation for Data Products Corp., Culver City, Calif.

L. M. Newberry: Named manager, support concepts, *MMRBM* program, at the San Bernardino, Calif., Operations of Aerospace Corp.

C. A. Zimmerman: Promoted to manager of propulsion engineering at Lockheed Missiles & Space Co.'s research and development division, Sunnyvale, Calif.

L. J. (Pat) Hines: Appointed assistant to the president at Mesa Scientific Corp., Inglewood, Calif.

Richard C. Amidon: Appointed manager of program development for Fairchild Stratos Corp.'s new data systems engineering organization, Hagerstown, Md.

Francis B. Kilduff: Appointed defense products manager of Instrument Development Laboratories, Attleboro, Mass.

Chris Musello: Named marketing manager for Solvere, Inc., Santa Anna, Calif.

Gerald Eyrich: Appointed quality assurance manager of Leach Corp.'s *Relay* Div., Los Angeles.

Gordon M. Elsner: Appointed marketing director of Janco Corp., Burbank, Calif.

Stanley Demain: Named general manager of the Stratos Div. of Fairchild Stratos Corp., Bayshore, N.Y.

Carl D. Strickland: Appointed a contracting engineer in the Atlanta, Ga., office of Chicago Bridge & Iron Co.

Carl A. Georgi: Named vice president and general manager of Pickard & Burns Electronics, Waltham, Mass.

Fred A. Klemach: Joined Sperry Rand Corp.'s Aerospace Div. Marketing Group, Detroit, as manager of systems development.

Wesley Tannenbaum: Appointed principal engineer at Space Sciences, Inc., Waltham, Mass.

N. M. Graham: Named director of materiel for Martin Co.'s Denver Div., Colo.

Dr. Lawrence M. Liggett: Named assistant technical director at Speer Carbon Co., St. Marys, Pa.

Glenn H. Lohuis: Promoted to director of sales at Chicago Aerial Industries, Barrington, Ill.

Nathan Bylock: Named vice president and manager of Measurement Control Devices, Philadelphia, Pa.

Dr. Murray Disman: Appointed manager of the microwave tube division of Eitel-McCullough, Inc., San Carlos, Calif.

Robert L. Tillotson: Appointed vice president and manager of the Central Regional liaison office of the Systems Group of Litton Industries, Dayton, Ohio.

Tom W. Le Nay: Named president of Perkin Electronics Corp., El Segundo, Calif. George W. Mousel named vice president.

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ASTME Annual Meeting, Convention and Exposition, Detroit, April 20-24.

Seminar on Nonlinear Partial Differential Equations in Mathematical Physics, sponsored by AF Office of Scientific Research, Army Research Office, American Mathematical Society, Hotel New Yorker, New York City, April 20-23.

First Canaveral Space Congress, sponsored by Canaveral Council of Technical Societies, Ramada Inn, Cocoa Beach, Fla., April 20-22.

AFIPS, IEEE and ACM Spring Joint Computer Conference, Sheraton-Park Hotel, Washington, D.C., April 21-23.

IEEE Southwestern Conference and Electronics Show, Dallas Memorial Auditorium, Dallas, April 22-24.

American Geophysical Union, Annual National Meeting, Washington, D.C., April 22-25.

Fourth Rare-Earth Research Conference, sponsored by AF Office of Scientific Research, Phoenix, Ariz., April 22-25.

Society of American Value Engineers Annual Meeting, Ambassador Hotel, Los Angeles, April 23-24.

The Combustion Institute, Western States Section, Spring Meeting, San Jose, Calif., April 27-28.

National Aeronautics Meeting and Production Forum, sponsored by SAE and ASME, Commodore Hotel, New York City, April 27-30.

IEEE and ISA Region 6 Annual Conference, Salt Lake City, Utah, April 29-May 1.

National Aeronautics and Space Administration's Annual Conference on the Peaceful Uses of Space, Boston, April 29-May 2.

Institute of Navigation, Space Navigation Meeting, Port-O-Call Inn, St. Petersburg, Fla., April 30-May 1.

MAY

American Society for Microbiology, Sheraton Park and Shoreham Hotels, Washington, D.C., May 3-7.

10th National Aerospace Instrumentation Symposium, sponsored by ISA, Biltmore Hotel, New York City, May 4-6.

AIAA Aerospace Propulsion Meeting, Cleveland, May 4-6.

10th Annual Meeting of the American Astronautical Society, Hilton Hotel, New York City, May 4-7.

ASME Metals Engineering Conference, Sheraton-Cadillac Hotel, Detroit, May 4-8.

Second National Biomedical Sciences Instrumentation Symposium, Instrument Society of America, University of New Mexico, Albuquerque, May 4-7.

IEEE Fifth National Symposium on Human Factors in Electronics, San Diego, Calif., May 5-6.

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editorial . . .

The Philosophy of Chance

BEHIND THE MISSILE CONTROVERSY between Secretary of Defense Robert S. McNamara, on the one hand, and such public figures as Air Force Chief of Staff Gen. Curtis LeMay and Sen. Barry Goldwater on the other, lies an interesting dispute in military philosophy.

Secretary McNamara summarizes the situation pragmatically in this fashion:

- The U.S. has 750 intercontinental ballistic missiles on the pads as against less than 200 Soviet ICBM's.
- There are 192 *Polaris* missiles deployed, in contrast to a far fewer number of Russian sub-launched missiles which have only one-third as much range and must be fired from the surface.
- The U.S. has 540 strategic jet bombers on 15-minute alert, while Russia has no more than 120 heavy bombers and 150 medium-range bombers capable of hitting U.S. targets on two-way missions.

To Secretary McNamara, these figures mean just one thing. The U.S. has such an overwhelming strategic superiority that it can absorb a nuclear first strike and still inflict unacceptable damage on the enemy. He knows this and he is convinced the Russians also know it. Furthermore, the Secretary has such a high level of confidence in our intelligence capability that he believes we will be amply forewarned should there be any Soviet developments which might change this situation.

Gen. LeMay and Sen. Goldwater do not share the Secretary's confidence.

For one thing, they are seriously concerned about the vulnerability of our ICBM force—vulnerability, not reliability. It is possible to insure against even a low level of reliability by deploying sufficient missiles against vital targets so they will be hit even should half the missiles fail to reach target. This is not to suggest that the U.S. ICBM reliability is that low. It is not. But if it were, military planners could take it into account.

Vulnerability, for a nation conceding the first strike, is a different problem. We are not at all certain how well our ICBM force will survive electromagnetic pulse, earth shock and other imponderables of a nuclear attack. Deployment of additional missiles is not a protection against vulnerability. It is this which is worrying Gen. LeMay and Sen. Goldwater.

They fear, and rightly so, that complete dependence upon ICBM's might leave the U.S. in an untenable position. This would be valid if two things were true: 1) That U.S. ICBM's were indeed vulnerable. This is open to question and in view of the present Soviet weakness in ICBM's, not a major current problem. 2) That Secretary McNamara did intend to depend solely on ICBM's. We have seen no evidence of this. It is true that the Secretary has not been moving as fast toward a new manned strategic aircraft as Air Force proponents would like. But he has shown an awareness [illegible] requirements in this area and we anticipa[illegible]elopment of just such an aircraft.

We believe that if the Secretary and his staff are open to criticism in this dispute, it is in an area other than the two just mentioned. When the Secretary of Defense contemplates the strategic position of the two nuclear powers, he sees an overwhelming superiority in favor of the U.S. With this in view, he sees no need for the additional strategic kill-power of another manned aircraft, or a low-altitude missile or a medium-range ballistic missile emplanted in Europe or aboard a surface fleet.

His reasoning on this is valid—if we have absolute assurance that the Soviets will not come up with a surprise development which might counter our present and planned ICBM strength. We consider it reasonable that they might do so, and we consider it unreasonable to assume that we will have years of advance notice so that we can proceed to deploy other deterrent forces at leisure. Overwhelming superiority in ICBM's is comforting, but not as comforting as that same strength deployed in a mixed force which provides the U.S. with insurance against unforeseen Soviet developments such as achievement of an effective anti-ICBM weapon.

This might turn up as something the size of a small car and be deployed before we were aware of it. Unlikely? Yes. Impossible? No. And we must be protected against the unlikely as well as the likely.

An Air Force officer, Col. Francis X. Kane of AF Systems Command, has authored an article in the April issue of *Fortune* which brings to light some of the controversy within the Pentagon on military planning. He believes that we are placing too much dependence on computerized planning in our defense establishment, and thereby are eliminating our ability to cope with the unpredictable, in order to construct models and manipulate them mathematically.

Says Col. Kane, "We need masses of data on repeated events. This necessitates the discarding of data on individual events that do not fit into the mass. Such 'unique' events lie principally in the field of decisions that have occurred only once in history—e.g., the Japanese decision to attack Pearl Harbor, the U.S. decision to defend South Korea, the Soviet decision to put missiles into Communist Cuba. These individual acts of will cannot be handled by scientific methodology."

As the Colonel points out, nearly all discoveries and inventions could be shown to be rationally impossible before they were made. As he says, "discovery nearly always comes by chance."

WE THINK THE COLONEL'S VIEWS deserve wide reading in the Pentagon, although we take exception to his desire to pin a weird new label on what is no more than plain common sense.

Nor do we share his pessimistic view that the men at the top do not possess this common sense. They desire to reduce to figures all that can be so reduced—but we do not believe they have thrown out all regard for intuition. They merely wish to separate what must be intuitive from that which does not have to be intuitive. This is a worthwhile objective—if the colonel's words of warning are kept in mind.

William J. Coughlin

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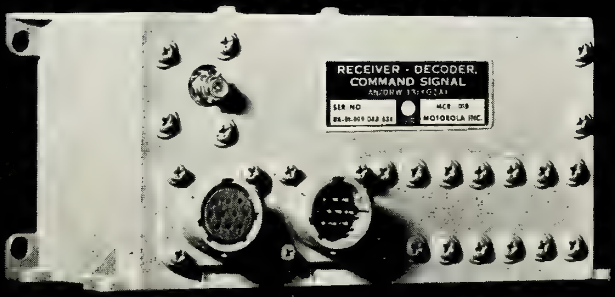

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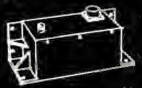

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missiles and rockets

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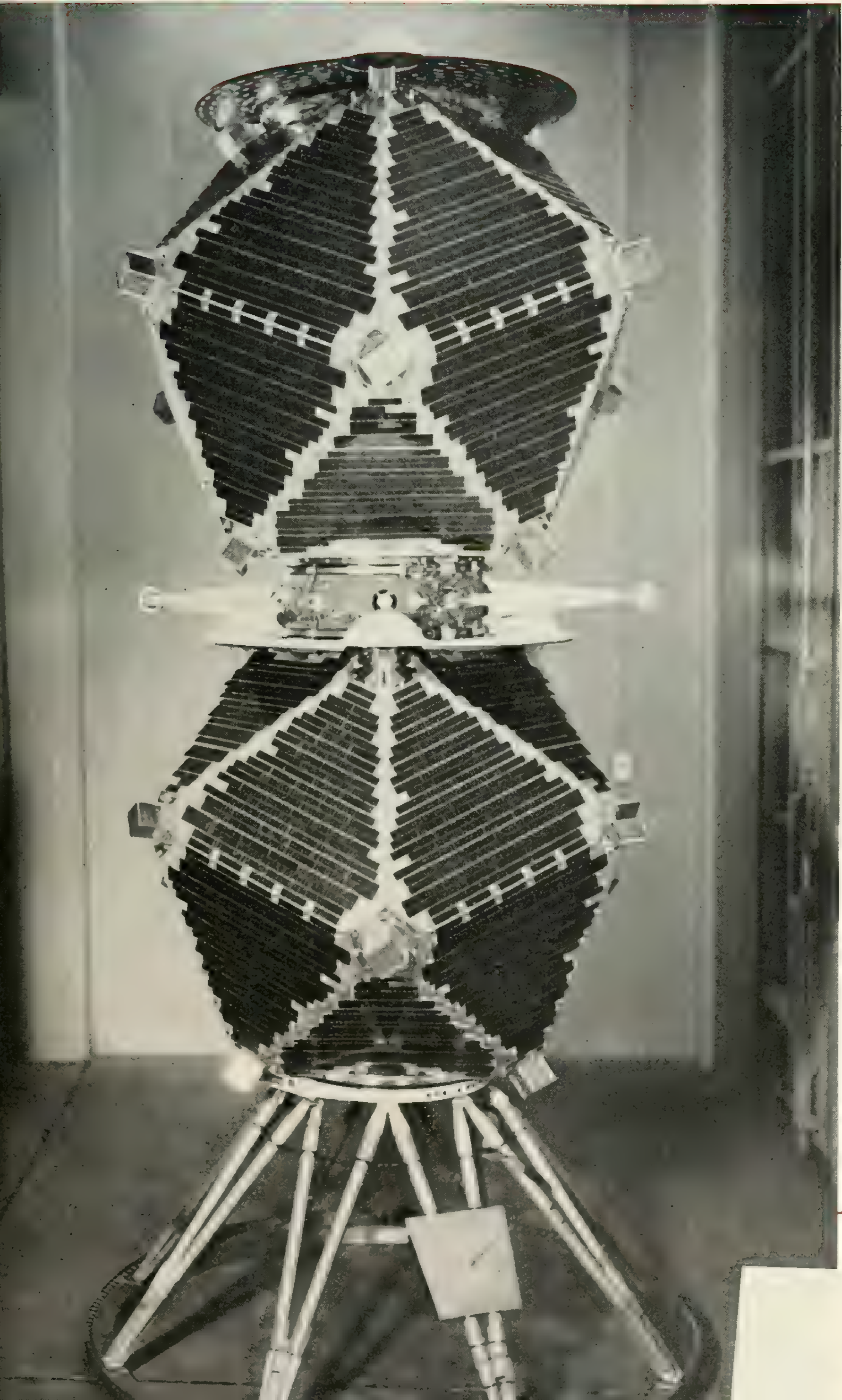

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For immediate consideration, write: Mr. J. N. Love, Huntsville Staffing Department, Lockheed Missiles & Space Company, P.O. Box 504-L, Sunnyvale, California.

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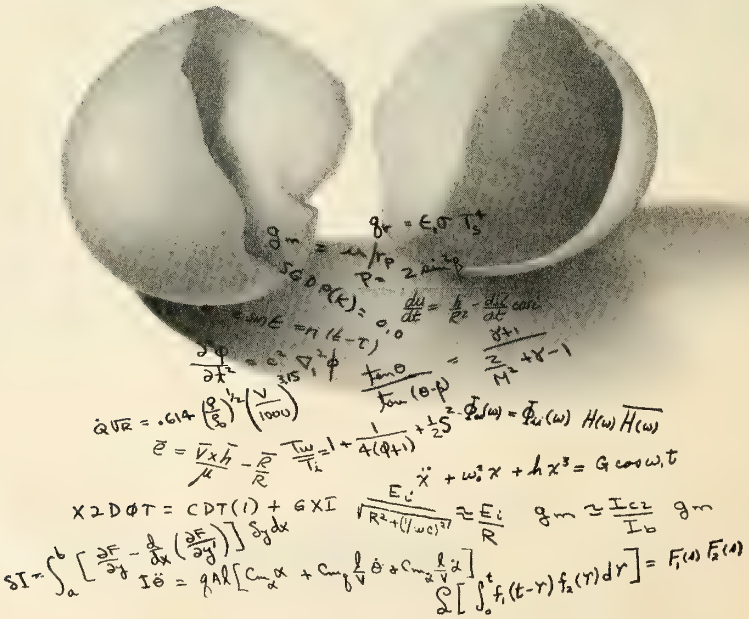
$q_r = \epsilon_i \sigma T_s^4$
$\frac{\partial^2 \phi}{\partial t^2} = c^2 \nabla_1^2 \phi$
$\frac{\tan\theta}{\tan(\theta-\beta)}$
$\dot{Q}\sqrt{R} = .614 \left(\frac{\rho}{\rho_0}\right)^{1/2} \left(\frac{V}{1000}\right)^{3.15}$
$\Phi_o(\omega) = \Phi_{ii}(\omega)\, H(\omega)\, \overline{H(\omega)}$
$\bar{e} = \frac{\bar{V} \times \bar{h}}{\mu} - \frac{\bar{R}}{R}$
$\frac{T_w}{T_i} = 1 + \frac{1}{4(Q+1)} + \frac{1}{2}S^2$
$\ddot{x} + \omega_0^2 x + h x^3 = G \cos \omega_1 t$
X2DØT = CDT(1) + GXI
$\frac{E_i}{\sqrt{R^2 + (1/\omega C)^2}} \simeq \frac{E_i}{R}$
$g_m \simeq \frac{I_{c2}}{I_b} g_m$
$\delta I = \int_a^b \left[\frac{\partial F}{\partial y} - \frac{d}{dx}\left(\frac{\partial F}{\partial y'}\right) \right] \delta y\, dx$
$I\ddot{\theta} = qA\ell \left[C_{m_\alpha} \alpha + C_{m_q} \frac{\ell}{V} \dot{\theta} + C_{m_{\dot\alpha}} \frac{\ell}{V} \dot{\alpha} \right]$
$\mathcal{L}\left[\int_0^t f_1(t-\tau) f_2(\tau) d\tau \right] = F_1(s) F_2(s)$

missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING

Volume 14, Number 17

April 27, 1964

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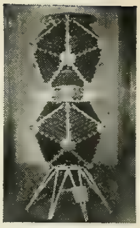
THE COVER



These twin, vertically stacked nuclear-detection satellites (originally designated Vela Hotel) are being shown to the public for the first time at the New York World's Fair. Two such satellites, manufactured by TRW Space Technology Laboratories, were launched tandem aboard an Atlas-Agena last Oct. 16 from Cape Kennedy. They're designed to detect nuclear explosions at up to 100 million miles in space from an orbit 60,000 miles high. See p. 11.

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48,098 copies this issue

† U.S. Reg. Pdg.

Is this
what most engineers mean
when they say
RELIABILITY?

An integrated guidance, control and checkout system that must be buried in a silo for years and ready to function perfectly at a moment's notice.

That is reliability. These are the systems which keep the Minuteman ICBM continually alert and put it on target. They were designed, developed and produced by the Autonetics Division of North American. All goals, including reliability improvements of 100 times, were met or exceeded — under cost target and ahead of schedule. A year of on-station experience for the D17 computers shows an average of 10,000 hours operating time between failures. For the complex C53 guidance and control console which talks to the computer 24 hours a day, it's 30,000 hours. And the electro-mechanical nozzle control units rate 55,000 hours between failures. Now Autonetics is leading the industry into production application of microelectronics for even greater Minuteman reliability and performance. These are but some of the many achievements by engineers and scientists at Autonetics in integrated, cost-effective systems. These achievements set the standards of reliability for the entire electronics industry.

North American Aviation/Autonetics

letters

Management Analysis

To the Editor:

Since we are currently analyzing everything for its cost/effectiveness ratio, it is my suggestion to Air Force policymakers that they analyze their management teams from that point of view.

I believe they will find, at least at the lower levels, that in spite of their considerable cost their only true effectiveness is in:

1. Engineer-baiting
2. Engineer-downgrading
3. Obstructing engineer effectiveness
4. Abuse of authority

Were this analysis carried out on these technical illiterates, their cost/effectiveness ratio would make the *Skybolt* look like the biggest bargain DOD ever had.

Tony Berger
Burbank, Calif.

The Bovine Approach

To the Editor:

After much serious discussion concerning the problems involved, and a preliminary investigation of the technical difficulties we have arrived at what we consider a suitable alternative to JPL's *Ranger* series. We feel that attaching television cameras to a cow and training it to jump over the Moon represents a significant increase in the state of the art. Our process engineering branch assures us that while the results may be the same as in the JPL series, certainly the program will be considerably less expensive.

We do not intend to patent this idea, but offer it freely as our contribution to the space race.

Charles Dickinson
James R. Holden
Washington, D.C.

Echo Silhouetted

To the Editor:

The shape of the balloon satellite *Echo II* has been under discussion in the press recently. Radar cross-section measurements were reported to be variable and less than predicted. The idea of photographing the balloon was derided because "optical telescopes are not powerful enough to provide an accurate picture."

The above quote probably referred to viewing the satellite by reflected light, whereby a specular image of the Sun would be seen. It might be interesting instead to examine *Echo II* when it is silhouetted against the Moon.

A quick calculation shows that *Echo II* subtends an angle which varies from 6.5 to 8.5 seconds of arc. This is within the resolution capability of a one-in. lens! In practice, however, in order to resolve circular distortion of the silhouette, a lens larger than 10 in. would be needed.

The apparent speed of the silhouette across the Moon will be about 200 mi. per second. It will traverse its own diameter in about 0.05 seconds. A shutter speed of 0.005 seconds should suffice. The camera should have a precision plate holder rather than ordinary film. As many pictures as possible should be taken for two reasons: namely, *Echo* is rotating on its own axis, and atmospheric refraction may amount to many seconds of arc. A Moon near the zenith would minimize refraction. Observation by eye would neutralize refraction effects, also.

The writer got this idea while watching *Echo II* on a "near-miss" pass at the Moon recently. It would be interesting to have a computer programmed with the ephemerides of the Moon and of *Echo*, and also with the "geoides" (sorry) of known observatories, to determine when the satellite (dark) will cross the (illuminated) Moon, and finally, to observe or photograph the silhouette.

W. C. Lawson
Western Electric Co.
Adelphi, Md.

'Civilized' Military

To the Editor:

I believe one of your statements in the April 6 editorial ("The Revolution: Part II") should be re-examined.

You stated of Secretary McNamara: "For the first time the military services were dealing with a man capable of doing just exactly what Congress had instructed him to do—unifying the Pentagon into a single effective military establishment."

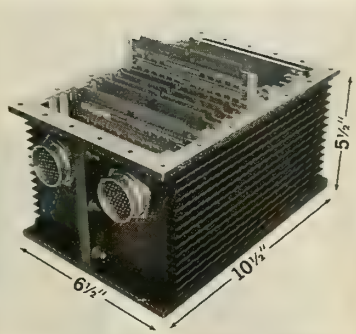
The statement is entirely true with one exception. The word "military" should not have been used to describe the establishment resulting from McNamara's management.

An example of the extent to which civilian attitudes have come to dominate the establishment may be found in the article "Brief Critique: Line Duty Peril" in the April 11 issue of the *Army-Navy-Air Force Journal and Register*. Mr. Daniel Z. Henkin, an assistant editor for the *J&R*, describes the difficulty which the various Services are having in obtaining volunteers for officer vacancies in command positions. Our young officers have learned that, whereas preparation for combat was once the principal duty of a military man, the most valuable service he can now render his country is from a staff position where he can insure that government money is not wasted. Since war is impossible because of our superb deterrent missile and bomber force (still slightly larger than Russia's), it is clear that any money spent preparing to fight is wasted.

Therefore, our young officers must try for staff positions where they can learn the latest techniques for using computers to discover reasons for terminating weapons systems just before we waste money by putting them in the hands of (ugh) fighting men. We have, indeed, thoroughly "civilized" the (ex)military establishment.

Robert J. Reithel
Los Alamos, N.M.

And is this what most engineers mean when they say APPLIED MICROELECTRONICS?



It is called the D26J computer.

Actually, the D26J is part of the MONICA family of microelectronic computers designed and put in production by the Autonetics Division of North American Aviation.

The MONICA family of data processors has a reliability of thousands of hours of failure-free operations and a capacity far greater than the famed Autonetics VERDAN computer. With the same careful design engineering that produced the VERDAN and MINUTEMAN computers, MONICAs are for advanced military applications.

A central data processing member—the D26C—of the MONICA family has a random access, magnetic core memory which retains 8,192 words (expandable to 32,768 words) and a rapid access memory of 256 words, one microsecond cycle time. Its 30-bit word format provides the precision required for most applications without requiring double precision subroutines.

A minimal guidance machine, the D26J is .15 cubic feet and weighs just 13 pounds. The central data processing D26C is .65 cubic feet and weighs 40 pounds.

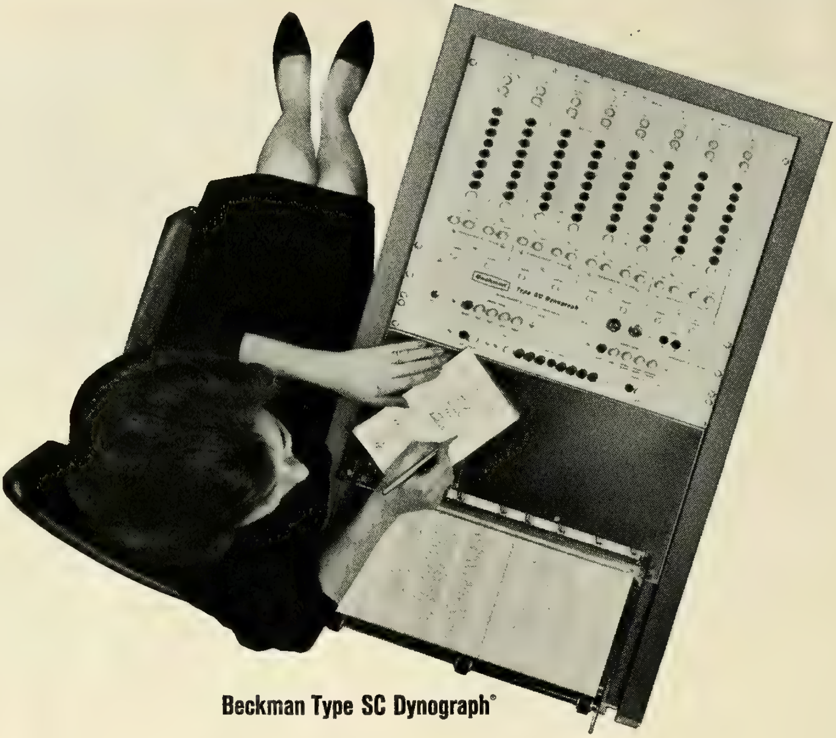
The MONICA family of computers is designed to combine high reliability and large capacity with building block flexibility. Their ease of maintainability assures total cost effectiveness.

A related microelectronic computer is the D37B. Its rotating disk memory and 6,966 word capacity of 24 bits, already has been tested and is in production for use in the WS-133B or MINUTEMAN II weapon system.

This is but one more example of how the engineers and scientists at Autonetics are forging ahead in the field of applied microelectronics and total systems integration... another reason Autonetics is setting standards for the entire electronics industry.

North American Aviation
Autonetics

New Ink Rectilinear Recorder for analog computer or telemetry write-out



Beckman Type SC Dynograph®

All the desirability of the Dynograph ink-rectilinear recorder, in a design for complete compatibility with analog computers

Famous Locked-In Accuracy at the tracing! Servo system constantly compares pen tip and input signal for maximum accuracy and linearity.

Reliable Solid-State Circuitry eliminates drift, component aging. No warm-up time; low total power consumption (230 w. max., for 8 channels).

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- Pressurized inking system
- Paper Capacity: 1,000 ft. high gloss maximum contrast
- Paper Take-up: Reel standard, optional take-up assembly available
- Paper Drive: Zero weave, 8 or 16 speeds
- Calibration: Operate, zero, calibrate, attenuator
- Overload Indicator: each channel
- Timing Marker: one/sec or remote; second marker optional

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The Countdown

WASHINGTON

Apollo Flight-Testing Approaches

First boilerplate Service Module of the *Apollo* spacecraft has arrived at the Manned Spacecraft Center for vibration testing. Two flight tests of *Apollo* systems also are scheduled for next month. A maximum Q test of the spacecraft abort propulsion system will be made at White Sands Missile Range, N.M., in mid-May, and a boilerplate spacecraft will be put into Earth orbit by a *Saturn I* booster from Cape Kennedy in late May.

New Underground Test Site Readied

Atomic Energy Commission is developing a new underground test area in the Pahute Mesa—northwest of the present Nevada Test Site. Located on the Air Force bombing and gunnery range, the site will provide for vertical drilling of test holes to depths of 4,000-5,000 ft. Experiments are scheduled to begin next month, with larger-yield shots.

Standardized Nuclear Test Container Developed

To achieve a greater degree of readiness in case the nuclear test ban treaty is abrogated, the AEC has developed a "drop envelope." Nuclear components of a particular test device are placed in the envelope along with standard triggering equipment, and the device is ready for test. The method is much faster than the old approach of building an entire weapon for a given test.

Centaur Shot Date Hinges on Checks

Results of a couple of tests this week will decide the launch date for *Centaur 3*. Purpose is to check a minor redesign incorporated to prevent air from getting under the insulation panels. Earliest date for the launch is sometime next month, but further slippage is possible.

Minuteman I Inadequacy Denied

The Air Force has scotched a report printed in an aerospace trade journal (not M/R) that the *Minuteman I* can't reach its target from its silo. Maj. Gen. W. Austin Davis, commander of the AFSC's Ballistic Systems Div., told reporters at Cape Kennedy last week that the "blooper" may have been based on some earlier feeling that Wing I *Minutemen* at Malmstrom AFB, Mont., had some range limitations. Davis said tests showed that the missiles actually exceeded their operational requirement.

Navy Winding Up Advanced Deterrent Study

A Navy group which has been studying concepts for an advanced sea-based deterrent for the past three years is expected to complete its work this summer. Following this, the four of five most promising schemes will be submitted to the Chief of Naval Operations and the Secretary of the Navy. The study is not limited to *Polaris* submarine types of systems but is free to examine all possible alternatives.

AF Advanced ICBM—A Sea Weapon?

One of the most promising concepts in the Air Force Advanced ICBM studies is an environmentally sealed missile which could be anchored to the offshore littoral of the U.S.—or any other land mass. Navy officials are aware of the program and have furnished information.

Carrier Forces Losing Strategic Role . . .

Not included in Secretary of Defense McNamara's recent analysis of relative U.S.-USSR strength were the carrier forces. Although in the past these have been counted as part of the strategic package, the Joint Chiefs of Staff and McNamara have agreed that, starting with the FY 1966 budget, they will revert to the General Purpose category.

. . . And BMEWS Is Officially Downgraded

In Dept. of Defense analysis of U.S. strategic retaliatory forces, the decreasing value of the Ballistic Missile Early Warning System has become apparent. With *Polaris* at sea and *Minuteman* in hardened and dispersed silos, the need for warning of an enemy missile attack has definitely declined. Developed to enable bomber forces to get off the ground before an attack, BMEWS is not obsolete but will be, according to the Air Force, "of less use in the future than it is now."

Space Station Observatory Envisioned

One potential use for a *Manned Space Station* being proposed by NASA is as an astronomical observatory—one that would greatly increase angular resolution and extend wavelength range beyond anything possible in Earth observatories. In order to achieve required pointing accuracies of 0.1 sec. arc on photographic exposures of one hour or more, an astronomical mission module with a radio command and an optical data link to the station may be placed in close proximity to the manned orbiting laboratory.

INDUSTRY

Big Firms Bidding for LLSS Study

Five firms—Bendix Systems Div., Boeing, Chrysler, General Electric and Grumman—have submitted bids to the Marshall Space Flight Center for the feasibility and design study of a payload for the *Apollo* Lunar Logistic Support System which would land on the Moon on the LEM truck vehicle. The contract is due to be awarded in mid-May.

GD/A Takes Aim on MOL Competition

General Dynamics/Astronautics has formed a new project organization devoted wholly to manned space systems and openly aimed at the Air Force's *Manned Orbiting Laboratory* program. Heading the group is Mortimer Rosenbaum, a company vice president second in command to president J. R. Dempsey. He formerly was vice president-research, development and engineering.

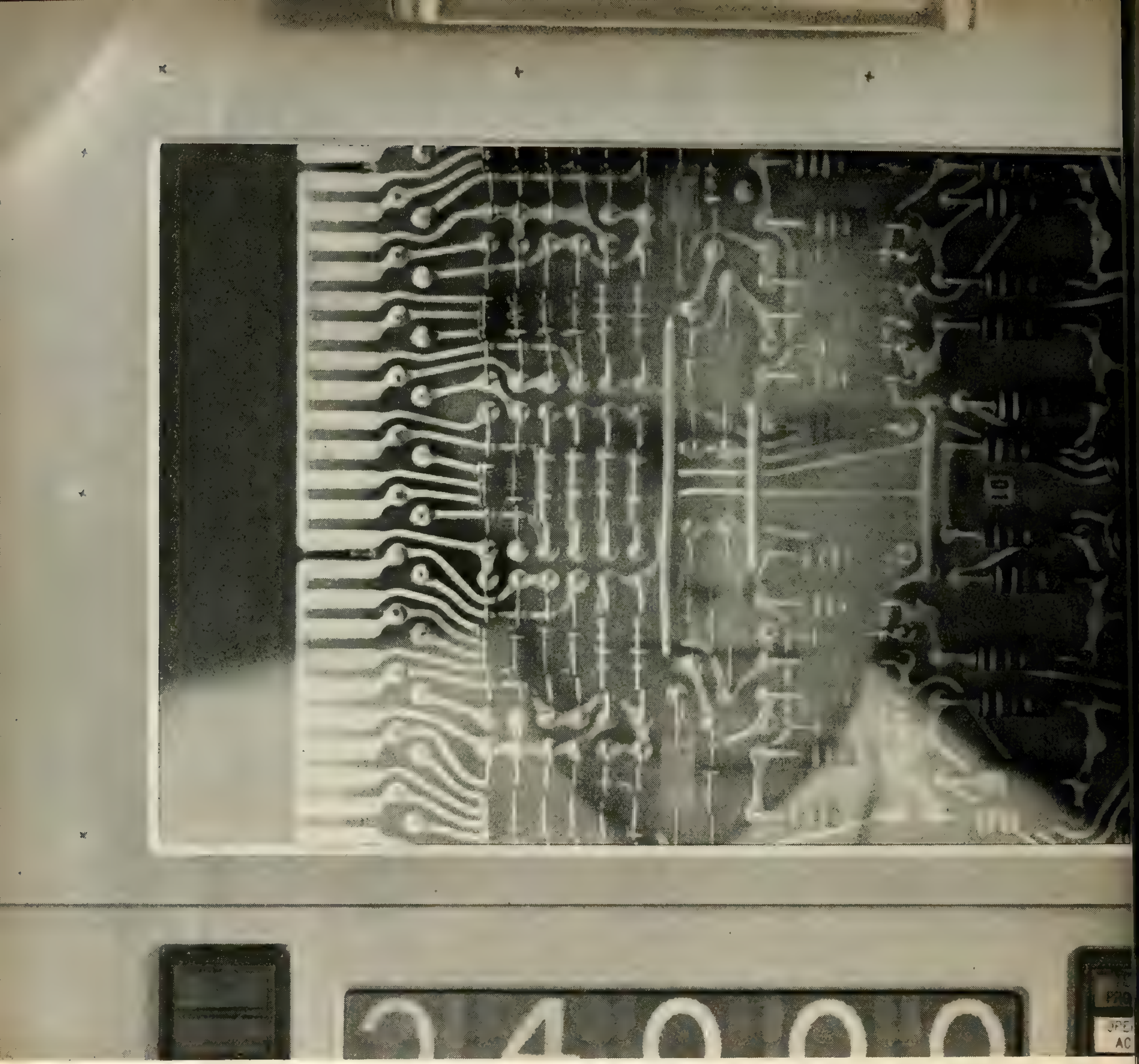
INTERNATIONAL

French Plan New Missile Firings Next Summer

Defense Minister Pierre Messmer says first launchings of Missiles from France's new Biscarosse Range (COUNTDOWN, April 20) will take place in mid-1965. Firings will be tracked by stations France will build in the Azores. Range of the French ballistic missiles will vary from 500 to 3,000 kilometers. The Biscarosse range will be staffed by 1,800 technicians in 1966 and by 3,000 in 1970.

Castro-Khrushchev Missile Hassle Possible

Cuban Premier Fidel Castro and Soviet officials may soon become embroiled in debate over control of the antiaircraft missiles being left in Cuba by the Russians. Operation of the *SAM* missiles is expected to be handed over to the Cubans on May 1, but the Soviets may try to keep veto power over their launching. This probably would be stiffly opposed by Castro.



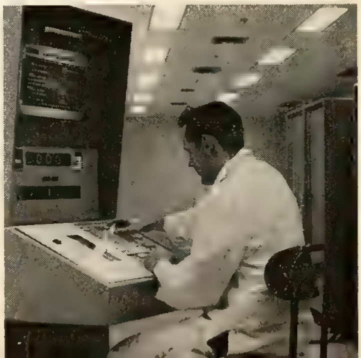
How to look into a "bird brain"

This is a picture of a circuit from the "brain" of an intercontinental ballistic missile. It is part of one of the most complex devices ever created, capable of guiding the giant "bird" over vast distances.

To give this kind of guidance system a regular checkup—making sure it will be ready for its vital mission—is a massive job. Until now, each type of "brain" had to have a custom-made tester to give it a checkup.

This was expensive. People had to be specially trained. And when a new system came along, a new tester was needed.

So the U. S. Air Force asked Hughes engineers to look at the problem. The assignment was to apply their unique experience in digital computers to build a tester which would automatically diagnose malfunctions in many different types of systems. It would be easy to operate. Self-testing. Easy to repair. And require fewer and less highly-trained operators.

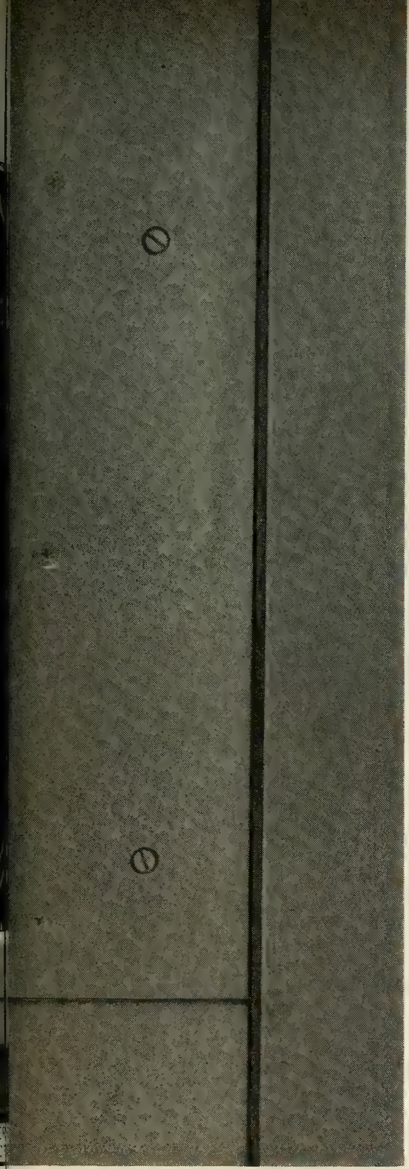


The answer, now in operation, is VATE—Versatile Automatic Test Equipment. This is a combination of digital computers and associated equipment in "building block" form. It can be programmed to do several tests simultaneously on a wide variety of systems. Because the computers can easily be re-programmed and the modules replaced, VATE will not go out of date. It can be inexpensively adapted

Now in operation at the Newark Air Force Station, Heath, Ohio, VATE "knows" so much it can predict a breakdown before it happens by sensing minute changes in performance which might ordinarily escape notice.

Creating a new world with electronics

HUGHES



to future systems. And, over the years can save millions in defense costs.

Hughes is currently building a variety of testers. VATE for the largest, most complex systems. The HCM-111A, a "junior" VATE for flight line operations. The new VET for automatic auto engine testing. These testers exemplify Hughes role in creating more efficient, more economical electronics systems.

Engineers and scientists interested in the advanced electronics projects underway at Hughes are invited to write Mr. S. L. Gillespie, Manager, Employment and Manpower, Hughes Aircraft Company, Culver City 73, California. Hughes is an equal opportunity employer.

The Missile/Space Week

House Begins Ranger Probe

The NASA Legislative Oversight Subcommittee of the House Space Committee launches its probe of the *Ranger* program (M/R, Apr. 13, p. 15) this week with witnesses from NASA, Jet Propulsion Laboratory and industry.

Dr. Homer Newell, associate administrator for space sciences, will lead off Monday, accompanied by Edgar Cortright, deputy associate administrator, and members of NASA Headquarters *Ranger* office.

Wednesday the subcommittee, which will be headed in this investigation by Rep. Joseph Karth (D-Minn.), will hear Dr. W. H. Pickering, director of JPL.

Thursday industry representatives from Radio Corp. of America and Northrop Corp. will testify. These companies would have had major management responsibilities in the block of five *Ranger* spacecraft which were subsequently cancelled.

The subcommittee expects to conclude open hearings Friday after hearing from NASA Administrator James E. Webb and Associate Administrator Dr. Robert Seamans.

The House Space Committee scheduled the special sessions after receiving a letter from NASA Administrator Webb, which appeared to place much of the blame for failures in the *Ranger* program on Jet Propulsion Laboratory.

Shots of the Week

The Navy on April 20 launched two *Polaris A2* missiles from the nuclear submarine Henry Clay off the coast of Florida.

- The Air Force launched a satellite of undisclosed type aboard a *Thor-Ablestar* vehicle from Vandenberg AFB, Calif., April 21. No further details were released.

Vela Program Expanded

The "complete success" of the first *Vela High Altitude* nuclear detection satellites launched last October has led DOD's Advanced Research Projects Agency to expand and reschedule the program.

Future launches of *Vela High Altitude* have been stretched out by rescheduling to permit incorporation of major improvements between each launch, according to ARPA director Dr. R. L. Sproull.

Dr. Sproull said that as *Vela* R&D continues in the more favorable technological climate, "particular emphasis will be placed on developing a capability to detect bursts low in the atmosphere."

Northrop Gets Lifting Body Pact

Norair Div. of Northrop Corp. has been awarded an estimated $1 million contract to design and build two low-speed lifting body research gliders, which will be flight-tested in 1965.

The gliders will be about 20 ft. long and weigh 7,000 lbs. maximum. First delivery is expected in two months. During the flight tests, the gliders will be dropped from a B-52 and landed at Edwards AFB, Calif.

The gliders are designed to provide information on the problems of piloting large spacecraft during landing. They will be based on the M-2 lifting vehicle developed at the Flight Research Center and the HL-10 lifting body concept developed at the Langley Research Center.

Computer Access Simplified

A small system using simple, reasonable language is being developed by scientists at the Rand Corp., Santa Monica, Calif., for direct communication with a computer.

Dubbed JOSS for Johniac Open Shop System, the method was disclosed at the April 21-23 Spring Joint Computer Conference in Washington, D.C.

The system allows engineers and scientists on-line access to a computer through an electric typewriter using simple codes—essentially functioning as a high-speed calculator extension to the operating scientist.

The JOSS approach allows interruptions and simple clean-up steps in reaching total solutions to certain types of problems. The programmer is no longer needed as a middle man. At Rand, Johniac is coupled to a special-purpose buffer that handles messages between remote typewriter consoles.

Although still in the experimental stage and by no means a total answer to the user-computer relationship, the JOSS approach has proven acceptable in applications by engineers at Rand without previous com-

WHAT'S NEXT FOR FREEDOM OF SIZE AND SHAPE . . .

material with a memory?

We think so. The satellites shown used just three of the many material firsts scored by Schjeldahl. Newest addition is material with a memory. Capable of being folded into a small package, it retains memory of fabricated shape which it assumes upon release in space and maintains due to its high modulus. Material with a memory makes possible capsule launching of reflective grid devices without the problem and weight penalty of inflation or rigidizing systems or plastic membranes. It extends the limits of size and shape.

Schjeldahl has extensive capability in a number of fields, proven by Satelloon experience.

- adhesive and heat sealing methods
- plastic-metal fabrication
- thermal control coatings
- vapor-deposited coatings
- flexible printed circuitry
- heavy load balloons
- laminations
- system design and testing
- material development
- Pyrex glass encapsulation (3000°A)
- micro-meteorite sensors

Let us relate our proven experience in these areas to your needs.

Write R. Slater, Mktg. Mgr.
Aerospace Division

G. T. Schjeldahl Co.
Northfield, Minn.

ECHO II, World's Largest Spacecraft, fabricated by Schjeldahl for NASA of 0.18-mil aluminum foil on both sides of 0.35-mil Mylar*. Inside and outside of 135-foot Satelloon® treated with inorganic thermal control coating.

**DuPont trademark for its polyester film*

ECHO I, A 100-Foot Satelloon, fabricated by Schjeldahl for NASA of 0.5-mil Mylar with 2500°A coating of vapor-deposited aluminum. Still orbiting after 3½ years.

12-FOOT Atmospheric Density Satellite, built of Schjeldahl laminate of four layers alternating 0.5-mill aluminum and 0.5-mil Mylar. Seams are GT-301® thermal setting tape.

Putting Tomorrow's Materials to Work Today

GT Schjeldahl / AEROSPACE DIVISION

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puter experience. The method bridges the gap between the desk calculator and Fortran-type languages. The on-line aspect puts the user in a conversational situation with the computer.

The first commercial solid-state computer system to combine standard analog and digital techniques was unveiled at the meeting by its developers—Beckman Instruments, Inc. and Scientific Data Systems, Inc. The Beckman/SDS integrated computer system can solve advanced analog and digital problems both separately and in combination. Previously, two computers had to be used.

New Pact Bans Strikes at Cape

The Patrick AFB Contractors Assn. and representatives of the AFL-CIO have signed a three-year labor stabilization agreement, which includes a no-strike clause.

The agreement is retroactive to April 1, the termination date of the previous two-year contract. The new pact continues prevailing wage scale provisions of the earlier contract.

Lapse of the contract has received much of the blame for recent labor unrest at the Cape, the Merritt Island Launch Facility and Patrick AFB.

IBM Gets Saturn Award

NASA has selected IBM's Federal Systems Division as lead contractor for development and fabrication of instrument units (IU) for the *Saturn IB* and *Saturn V* launch vehicles.

IBM was selected by NASA in October, 1963, to design and manufacture the IU data adapters and digital guidance computers and be responsible for integration and checkout.

As lead contractor, IBM will assume the additional responsibility for the structural and environmental control systems and integration of all systems. NASA will supply the telemetry system and ST-124M stabilized platform.

Total cost of the IBM instrument unit work over the next five years is expected to exceed $175 million, $79 million of which has previously been announced.

The instrument unit, or "brain" of the *Saturn* vehicles, mounted between the *Apollo* spacecraft and the S-IVB upper stage of the *Saturn IB* and *Saturn V*, contains six major systems: structural, environmental control, guidance and control, measuring and telemetry, radio frequency, and electrical power. The IU is 22 ft. in diameter; external height is 3 ft.

Karth Sees Spending Decline

Rep. Joseph E. Karth (D-Minn.), chairman of the House Space Sciences Subcommittee, has told a meeting of the National Space Club in Washington that Government expenditures in space and other defense-oriented industries may now have passed the peak.

Questioned after his speech, Karth estimated that on the basis of information furnished to him by NASA, the post-*Apollo* programs will not increase that agency's annual budgets above the $5-6-billion level now forecast through the end of the decade. The DOD situation is even more severe, he said, citing estimated cutbacks in spending of $5-9 billion by 1970.

Second Rocket Victim Dead

The accidental firing of a *Delta Orbiting Solar Observatory* vehicle third stage at Cape Kennedy April 14 has claimed its second fatality, John Fassett, 30, a NASA project engineer assigned to the Cape.

Fasset died April 18 at the Brooke Army Medical Center, San Antonio, Tex., less than 24 hours after the death at a Cape Kennedy hospital of Sidney Dagle, 29, burned in the same accident. Dagle, a technician, was employed by Ball Bros. Research Corp., *OSO* prime contractor.

Davis Cites New Booster Need

Maj. Gen. W. Austin Davis, commander of the Air Force's Ballistic Systems Div., foresees difficulty in selling the nation on the need for new and larger rockets in the space program.

"We may have some difficulty in unhitching our space star from the ballistic (missile) wagon, when this last has become simply dead weight," Davis said in a speech to the first Canaveral Space Congress at Cape Kennedy last week.

He said the ballistic missile programs, which were vital to launching the space program, "conditioned the public to an acceptance of the practicality of flight beyond the atmosphere." But he warned that clinging to these proven systems to the neglect of developing "larger rockets not needed for ballistic missiles but necessary for future exploration of space" could wreck the space effort.

"It would not ensure us that 'banner of freedom and peace' in space which President Kennedy in 1962 pledged as our objective, and to which both civilian and military space efforts are dedicated."

WATCH DEI

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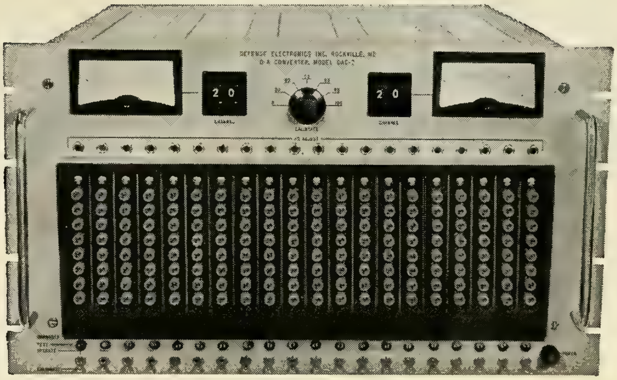

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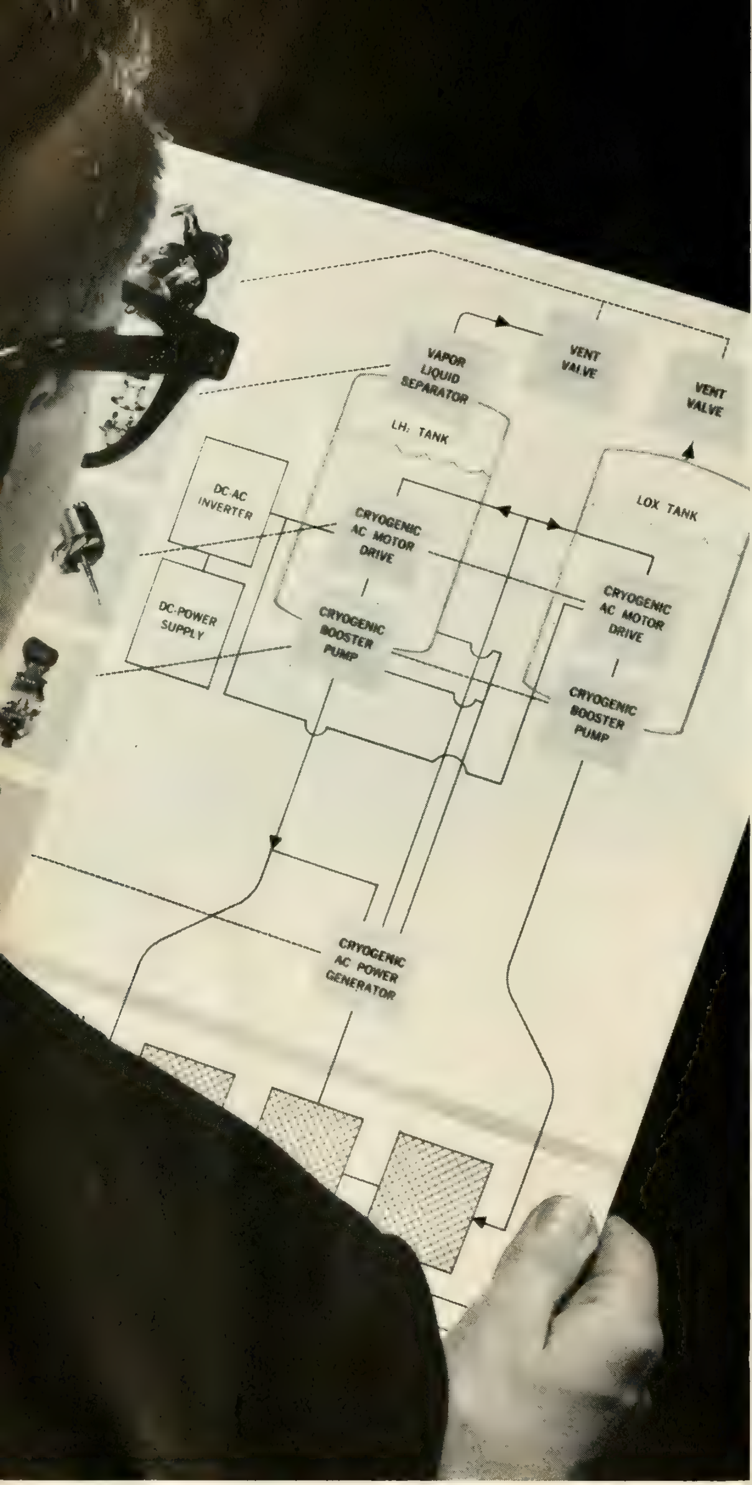
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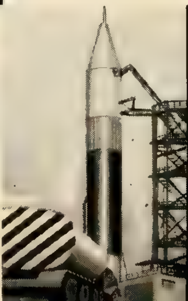

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DOD Has New Warhead Plan

Multiple re-entry vehicles would enhance missile penetration; Polaris A-3, Minuteman II are candidates

by James Trainor

MULTIPLE RE-ENTRY VEHICLES that will increase the penetration ability and the effect-on-target of U.S. strategic retaliatory forces are being actively developed by the Dept. of Defense. This advanced warhead technique is likely to be used in the *Polaris A-3* and the *Minuteman II* weapon systems.

In addition to the quantum improvement they offer in both penetrability and lethality, multiple warheads will have profound effects—politically and economically—on the nation's defense posture.

On the latter point, Defense studies have shown that, since the major costs of offensive weapons are the booster, launch complex and logistics requirements, significantly higher cost/effectiveness can be obtained with multiple re-entry vehicles. Defensive system costs rise rapidly when the problem becomes one of countering a missile carrying more than a single re-entry vehicle.

Politically, the importance of this development is pointed out by the April 16 enunciation at the Geneva Disarmament conference of a U.S. plan for freezing production of nuclear delivery vehicles. Essentially, force levels of missiles with ranges in excess of 621 miles for land-based—and 62 miles for sea-based—systems would be frozen. Although existing stockpiles would not be subject to inspection, production sites and launching complexes would be scrutinized by international teams.

In this situation, increasing the number of re-entry vehicles per missile would ensure continued U.S. superiority over the Soviets.

- **Embryonic stage**—This concept deals with the delivery of multiple reentry vehicles to multiple targets. In other words, once the booster has achieved the proper burnout velocity and angle, the re-entry vehicles themselves would be equipped with small auxiliary propulsion units that would enable them to hit different, although probably not widely separated, targets. This application is still in the embryonic stage and will be given much more study before it is applied to an operational system.

Much closer to operational use is the system in which multiple warheads are patterned onto the same target. DOD studies have shown that the probability of penetration—even assuming a fairly effective defense—approaches 1 as the number of re-entry vehicles increases. One study places the optimum number between five and 15 warheads with a 0.999 probability of at least one penetration and at least a 0.500 probability of more than one hit against an "effective" ballistic missile defense system.

Immediate application of the optimum multiple warhead technique is not likely, however. It is probable that the Defense Department will concentrate on the less arduous task of adapting three uniformly patterned warheads to a single missile.

Multiplying the number of warheads per missile reduces the yield of the individual re-entry vehicle, but at the same time reduces the size and radar cross-section of a single warhead. This increases the pentration capability of all the re-entry vehicles.

- **"Patterning" bursts**—The second technical advantage—greater effect on target—is achieved by "patterning" the warhead bursts. In effect, the re-entry vehicles are positioned so that maximum effect is obtained through the re-inforcing effects of blast and thermal radiation.

By varying the pattern, unusual or irregularly shaped targets can be attacked more effectively. For example, hard-point targets such as missile silos can be attacked by overlapping the nuclear detonations with kill probabilities as high as 0.50 achievable against 500-psi targets.

The main danger in this type of attack is the possibility that the re-entry vehicles may have to be concentrated in too small an airspace during the terminal phase—thus increasing the chances of one defensive warhead killing more than one re-entry vehicle.

Another example of warhead patterning is the use of multiple warheads to destroy elongated target complexes (such as airfields) by cratering. Cities, while considered "soft," are also irregular and maximum destruction can be achieved against them by patterning.

- **Blinding the defense**—By optimizing the number of re-entry vehicles (between five and 15), excess payload capability can be used for active and passive electronic countermeasure devices, decoys and bomb-damage assessment systems and their data links. A further sophistication would involve the use of a precursor warhead which would precede the re-entry vehicle covey. This precursor would be detonated above the enemy target complex, blacking out, or at least degrading, enemy missile defense radars.

Ground impact patterns of multiple warheads would be particularly sensitive to pointing errors before separation, variations in re-entry body weight and random errors effecting the individual warheads. Missile errors such as thrust misalignment, and incremental deviation in velocity-to-be-gained or roll, pitch and yaw errors would contribute to shifting of the entire impact pattern while individual re-entry body errors would result in deviations from the desired pattern.

Although an early application is promised, more sophisticated studies are now under way to take maximum advantage of multiple warhead techniques. In addition to the trade-off analyses between re-entry vehicles and decoys, effort is being concentrated on the effects of different warhead sizes on the same missile, re-entry spacing in relation to antimissile-missile kill radii, different W/C_DA's within the same booster envelope and missile accuracy as it relates to re-entry vehicle ground patterns. ■

With 120-day lifetime . . .

NASA Presses for Extended Apollo

Policy statement terms spacecraft essential to expanded manned flight program, poses first-generation orbital lab choices

by Hal Taylor

THE SPACE AGENCY, in a general policy statement on space stations, declares that an *Extended Apollo* spacecraft is essential to an expanded manned spaceflight program.

At the same time, NASA said that a decision will have to be made between three possible design concepts for a first-generation *Orbital Research Laboratory (ORL).*

The space agency's policy on space stations was spelled out by Michael I. Yarymovych, director of NASA's Manned Earth Orbital Mission Study Program, in a speech before the Canaveral Council of Technical Societies at Cape Kennedy April 22.

Yarymovych said the space agency, coordinating fully with the Defense Dept., is exploring four different types of orbital systems—*Extended Apollo, Apollo Orbital Research Laboratory (AORL), Medium Orbital Research Laboratory (MORL)* and the *Large Orbital Research Laboratory (LORL).*

The first three are all designed to be launched by the *Saturn IB*. The large laboratory would require the *Saturn V*. Initially all would be boosted into circular Earth orbits at altitudes of 200-260 mi. and at inclinations of about 28°.

- **Extended Apollo next**—After noting that the *ORL* system will be selected on the basis of results from the current study program, Yarymovych made it clear that the *Extended Apollo* —with an orbital capability of 120 days —will be NASA's next spacecraft development project.

He told the council that "it is becoming increasingly clear that the *Extended Apollo* is an essential element of an expanding Earth orbital program."

"In the initial stages," he said, "it would be used as a laboratory and later it could be converted to a logistics system."

He declared, however, that the *AORL, MORL* and *LORL* are competitive systems and a decision will have to be made as to which will serve as the best first-generation *ORL*.

He added that the Air Force's *Gemini-B/Manned Orbiting Laboratory* is being examined as a potential integral element of the *ORL* program.

While Yarymovych did not give any cost estimates for the various concepts, most space experts do not believe that the *LORL* will be feasible for a first-generation system because of its high cost and the *Saturn V* booster requirement. The *AORL* and *MORL* appear to be far more likely candidates.

- **AORL details**—*AORL* would be based on the *Apollo* spacecraft, with a laboratory section added that could support three to six astronauts. It incorporates a 5,600-cu.-ft. pressurized laboratory module in the adapter between the service module and the S-IVB booster stage made vacant by the removal of the Lunar Excursion Module.

Such a laboratory would be launched initially with a crew of three in the *Apollo* command module.

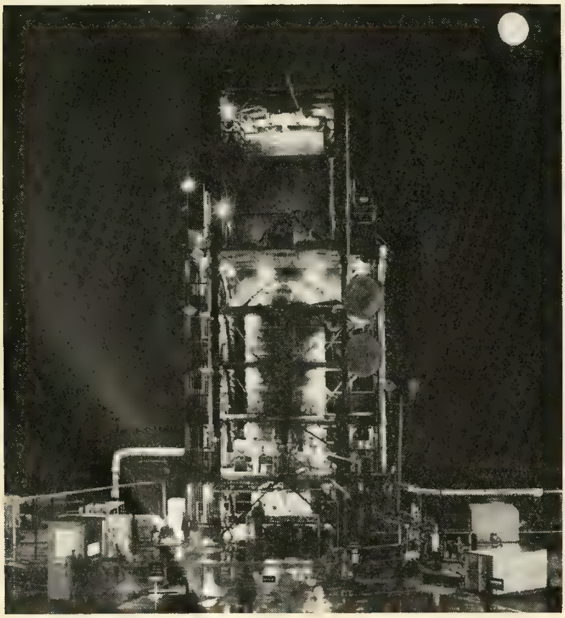
Another *Apollo* spacecraft could ferry up three additional crew members and supplies, which would dock at the opposite end of the laboratory.

From then on, for at least a year, on a three-month cycle, new *Apollo* ferries would deliver fresh crews and supplies or equipment.

MORL is directly comparable to *AORL* except that the laboratory would be launched unmanned by the *Saturn IB*. Because of the absence of the *Apollo* spacecraft, the laboratory would be heavier and larger, accommodating four to eight astronauts.

The basic laboratory, as presently conceived, is a sphere 22 ft. in diameter surrounded by a cylinder to make its aerodynamic shape compatible with the *Saturn IB* launch vehicle. The pressurized living volume is 5,700 cu. ft., with 2,800 cu. ft. devoted to experiments.

The design has two compartments, the upper equipped as living quarters and the lower as a laboratory. ■



Centaur by Night

ALTHOUGH launch of Centaur 3 has slipped at least into next month, preparations continue at General Dynamics/Astronautics for operational flights to the Moon beginning next year. The liquid hydrogen vehicle is here being readied for a test in its heavy walled propulsion test vehicle.

Committee Accepts ICBM Reliability

Full House unanimously approves FY 1965 defense appropriations bill of $46.76 billion; only $712 million is cut from request

by Heather M. David

THE HOUSE Appropriations Committee has put its weight behind Secretary of Defense Robert S. McNamara in the question of missile reliability.

In presenting the $46.76-billion Fiscal Year 1965 appropriations bill to the House, the committee said that "as a result of its analysis and consideration of all of the testimony taken, the Committee . . . is inclined to conclude with Secretary McNamara that 'on the basis of the evidence already in hand and our plans for the future . . . the missile force we have programmed can be depended upon to carry out its military mission under all of the conditions we can foresee.' "

The House passed the bill virtually as presented by the committee, 365 to nothing.

The bill amounts to $712 million less than the Department of Defense FY 1965 budget requests of $47,471,000. In this, there are cuts of $116 million in operation and maintenance, $318,053,000 in procurement, and $245,680,000 in research, development, test and evaluation. Some cuts had already been made by the Armed Services Committee in the authorization bill, however.

In presenting the bill, the Appropriations Committee voiced extreme concern about the nation's antisubmarine warfare effort, while otherwise commending the defense establishment.

Protection against submarine-launched missiles was singled out as a matter of great concern. "It is hoped that weapons such as the *Nike X* anti-ballistic missile system . . . could provide defense against submarine-launched ballistic missiles as well as those launched from land," the committee report said.

It indicated that the committee did not want to exhibit undue pessimism, but to call attention to the difficulties in ASW. "At the present time, the weapons which could destroy hostile submarines have a range exceeding that of the location and classification equipment."

The committee disclosed that the bill includes research efforts aimed at countering satellite-based strategic threats, "as well as significant improvements in satellite detection and tracking capabilities."

● **Procurement highlights**—One of the biggest single cuts in the bill, amounting to $81 million, was made in the various services' requests for electronics, including avionics and telecommunication systems and related equip-

DOD Insists It Is Developing New Weapons Systems

THE DEPT. OF DEFENSE made new disclosures about U.S. missiles in the third round of what now appears to be a running interchange between Secretary of Defense McNamara and Republicans in both houses of Congress.

In a letter to Rep. Melvin Laird (R-Wis.), the Secretary of Defense disclosed that:

—*Minuteman II* will have an accuracy twice that of *Minuteman I,* producing "the same improvement in effectiveness against hard-point targets as a yield increase of eight-fold." Payload capability is also increased by 30%.

—Total development cost of *Minuteman II* will be over $850 million, of which $700 million is included through Fiscal Year 1965.

—Total development cost of *Nike X* will exceed $1.5 billion. It will "have many times the effectiveness of *Nike-Zeus,*" and be "an almost completely new system."

—Total development cost of the *Lance* missile will be about $175 million, of which $50 million is funded in FY 1964 and $60 million planned in FY 1965. It will "replace the *Honest John* at an accuracy improvement of five-fold."

McNamara's letter essentially defended the Administration against the charge that it had not developed any new weapons systems. Besides those mentioned above, the letter listed the F-111 A and B, *Mobile Medium Range Ballistic Missile,* A7A aircraft, the Main Battle Tank, the Sea Hawk surface ship, EX-10, *Walleye* air-to-surface guided missile, and the *TOW* heavy assault weapon. In the military space program, the Secretary listed the *Titan III,* the Standardized Space Guidance System, "numerous special payloads," and the *Manned Orbital Laboratory.*

Laird made the charge in a speech to the House floor that only two of these constituted "new" systems—*Minuteman II* "an improved modification," and *Nike X* "significantly based upon already existing systems." He said "it's like saying that you have a brand new weapons system every time you change the model numbers."

ment. This action was taken to force better management and procurement practices, the committee indicated.

The Air Force received all the missile procurement funds ($1.730 billion) authorized for it, and Defense Agencies got all of the $498.7 million it had been authorized.

Both the Army and Marine Corps felt the axe in their requests for the *Redeye* missile program—amounting to cuts of $19 million for the Army, $10.5 million for the Marines. These were made on the basis that *Redeye* is not ready for the large production programmed in the budget.

The committee said that there was no question of the requirement for a weapon of this type, but that the request for production funds is denied "pending research and development efforts and proper utilization of procurement funds remaining from prior years."

A request by the Army for $29.7 million for *Shillelagh* weapon system was also refused on the basis that procurement funds "in the magnitude requested for this equipment, based on the stage of development at this time, could only serve to encourage . . . wasteful practices."

An Army mobile air defense program fund of $15 million was slashed on the grounds that no decision has yet been made as to actual weapons systems, and that granting of funds would be premature. Total Army procurement thus is $1.651 billion.

Navy aircraft and missile procurement funds were appropriated at $2.496 billion.

- **RDT&E highlights**—The committee deleted funds for the communications satellite system, for which $22 million had been asked by the Air Force and $1.5 million by the Defense Communications Agency, "in view of the uncertainty as to just what will result from the negotiations (with ComSat Corp.) and the fact that much of the money appropriated to the Air Force last year for this purpose has not been obligated."

The committee said that it would not recommend any further reductions in the *Mobile Medium-Range Ballistic Missile* program (see p. 21). "The Secretary of Defense can, if he chooses to do so, request the reprogramming of additional funds. . . ."

Total Air Force RDT&E funds allowed were $3.118 billion, and Army funds $1.340 billion.

Mismanagement and exercise of poor judgment in the *Typhon* program was cited as the reason for cutting $1 million in the Navy's new Advanced Surface-to-Air missile program.

Total Navy RDT&E amounted to $1.369 billion. ■

Joint Committee warns . . .

Failure to Flight-Test Tory Could Kill Pluto

THE JOINT (Congressional) Committee on Atomic Energy has warned the Atomic Energy Commission and the Dept. of Defense to make a decision "within the next year" to flight-test the Tory II-C device or face the termination of the Pluto program.

In a report accompanying the Fiscal Year 1965 AEC authorization bill, the committee also called for a major review of Project *Rover* as soon as certain critical tests are completed during the remainder of this year and in FY 1965.

Funds for flight-testing of SNAP 10 A were included in the authorizing bill, as expected (COUNTDOWN, April 6, 1964). The action was taken by the committee in spite of Administration reluctance to enter a flight program.

Total money authorized for the Atomic Energy Commission was $2.6 billion, only $28.5 million less than the AEC request.

- **Rover**—The joint committee granted the entire requested amount of $84 million in the nuclear rocket propulsion program. However, it pointed out that the current program does not include a flight-test objective, and called for review of the program after data from certain critical tests have been obtained.

"The committee believes that the *Rover* project is of great importance to the space program," the report said. It added that "the committee therefore intends to follow very closely the developments of the coming year with the hope that this program will lead to successful reactor design and operation."

- **Pluto**—The committee slashed $1.6 million from the $8 million requested for the Pluto program. It said that the amount authorized should provide for completion of Tory II-C tests, "which AEC witnesses indicated would probably exceed the $5 million identified for this purpose in the budget submission." The group stated flatly that the authorization would not include any funds requested by the Commission for advanced work leading to development of a Tory III reactor.

No criticism of the *Pluto* project or "those who have worked on it" was intended by the action, the Congressional group emphasized. However, it pointed out that Pluto is approaching "a crossroads foreseen by the Joint Committee in its report on the AEC authorization bill for fiscal year 1962."

The next step, which should lead to a flight test of the device, presents the possibility of an outlay of between $200 to $500 million and "considerable flight-test vehicle development work," the report stated. However, it pointed out that AEC witnesses had admitted that "it would be very hard to justify going on with the aerodynamic and engineering aspects of this system in order to test-flight," unless there were reasonable prospects for inclusion in a weapons system.

"The degree of expenditure involved in advancing this new and unique weapons system makes it imperative that the AEC and DOD make a responsible decision as to their future plans . . ." the committee said. The group said it would not approve further expenditures aimed at the development of a higher-performance reactor unless such decisions are made. "Unless a decision is made within the next year to flight-test the Tory II-C device, it is an unavoidable conclusion that the program should be terminated."

- **SNAP**—The committee authorized $77.6 million, $4.6 million more than the requested amount, for specific use in flight-testing the SNAP 10-A reactor in the spring of 1965. Total flight funds will be $14.6 million in FY 1965.

In making this provision, the committee said that "it wishes again to express its grave concern over the developing trend toward cancellation of successful projects immediately prior to their actual demonstration."

To partially offset the addition of these funds, the group suggested that $10 million be taken from other SNAP system improvement work, "such as the Mercury-Rankine cycle development."

A word of caution was expressed regarding SNAP 50. "First, the committee questions whether a level of funding such as that proposed for Fiscal Year 1965 ($17 million) is adequate to permit significant progress in view of the overall task envisioned."

In other actions, the committee granted all requests for raw materials, ($267 million), special nuclear materials ($401 million) and weapons ($771 million). ■

Restoration sought . . .

DOD Preparing Crucial Bid for MMRBM Funds

REPROGRAMMING ACTION under way in the Pentagon for the *Mobile Medium Range Ballistic Missile* (*MMRBM*) is expected to decide the fate of that system once and for all. Defense officials feel that if the two appropriations committees and the two armed services committees of Congress do not reconsider their cuts in the program, *MMRBM*, as presently envisaged, will be cancelled.

The request, reportedly now at Secretary of the Air Force level, asks for reinstatement of the entire $110 million originally requested. This would constitute Congressional approval of system development—something that the committees have been unwilling to give until an adequate operational concept for deployment of the system is presented.

● **Arguments for continuation**—No such operational requirement exists for the *MMRBM*, Defense officials admit, but they say there are three possible applications for the 11,000-lb., 2,000-mi.-range missile that warrant continued development of the mobile system. These are:

—Possible deployment of *MMRBM* as the weapon for the multilateral force, should that force come into being;

—Deployment as a replacement for some strategic weapons; and

—Missions that require rapid deployment to areas of the world, a lesson learned from Soviet missile deployment in Cuba.

For these reasons, plus a "visceral feeling" that a weapon of this type will be required in the future, DOD will ask Congress for reprogramming authority—probably after Senate passage of the Defense money bill.

If the request is refused, Director of Defense Research and Engineering Dr. Harold Brown has testified, Defense Secretary Robert S. McNamara "will cancel the full-scale development" of *MMRBM*. "I would agree with him that there is no point in trying to do a program that requires $110 million in Fiscal 1965 . . . on the basis of $40 million this year. I think it is better to kill it and start over again maybe with something enough different to have more appeal."

● **"Something enough different"**—Full-scale development of *MMRBM* is estimated at six to seven years at a total cost of $700 million. To date, some $100 million has been spent on the system. Already DOD is casting around for a less expensive alternative and has directed a reluctant Air Force to study other approaches.

Principal among these is use of the upper two stages of the *Minuteman*. A land-based *Polaris* and an extended-range *Pershing* have also been examined. All these alternatives have disadvantages, AF officials feel. The drawbacks are a loss of mobility, a consequent increase in vulnerability, a probable decrease in range, increased weight and other undesirable features.

● **Some worth saving**—If the reprogramming request fails to get approval, the Defense Department and the Air Force want to continue the stellar inertial guidance (STINGS) development and the command and control work. The House appropriations bill provides $40 million for the stellar guidance effort. This includes four stellar acquisition demonstration flights using *Polaris* boosters this year.

Applications of the stellar system beyond *MMRBM* include *Titan III*, derivatives of the *Manned Orbiting Laboratory*, and *MOL* ferry vehicles.

Funds available for continuing the command and control development are not spelled out in the bill, but AF officials feel that this effort deserves continued support. "On *MMRBM*," according to Lt. Gen. James Ferguson, AF Deputy Chief of Staff for Development, "a very fine job has been done and it is a very difficult area. It is a system that could apply to V/STOL aircraft or perhaps some Army application."

Many of the answers relevant to command and control of dispersed elements in the field are being developed in connection with *MMRBM*. Utilizing the results of this work would avoid the expense of developing a similar system to do the job. ■

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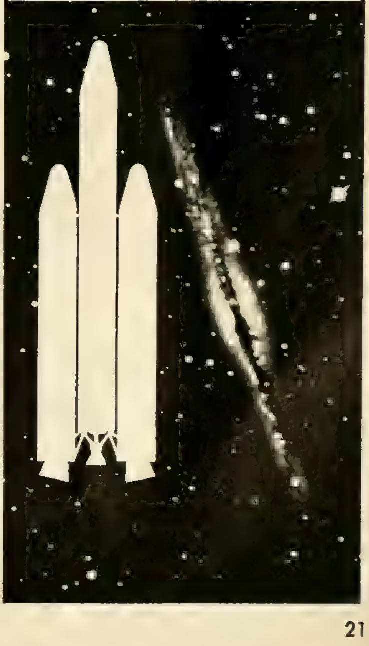

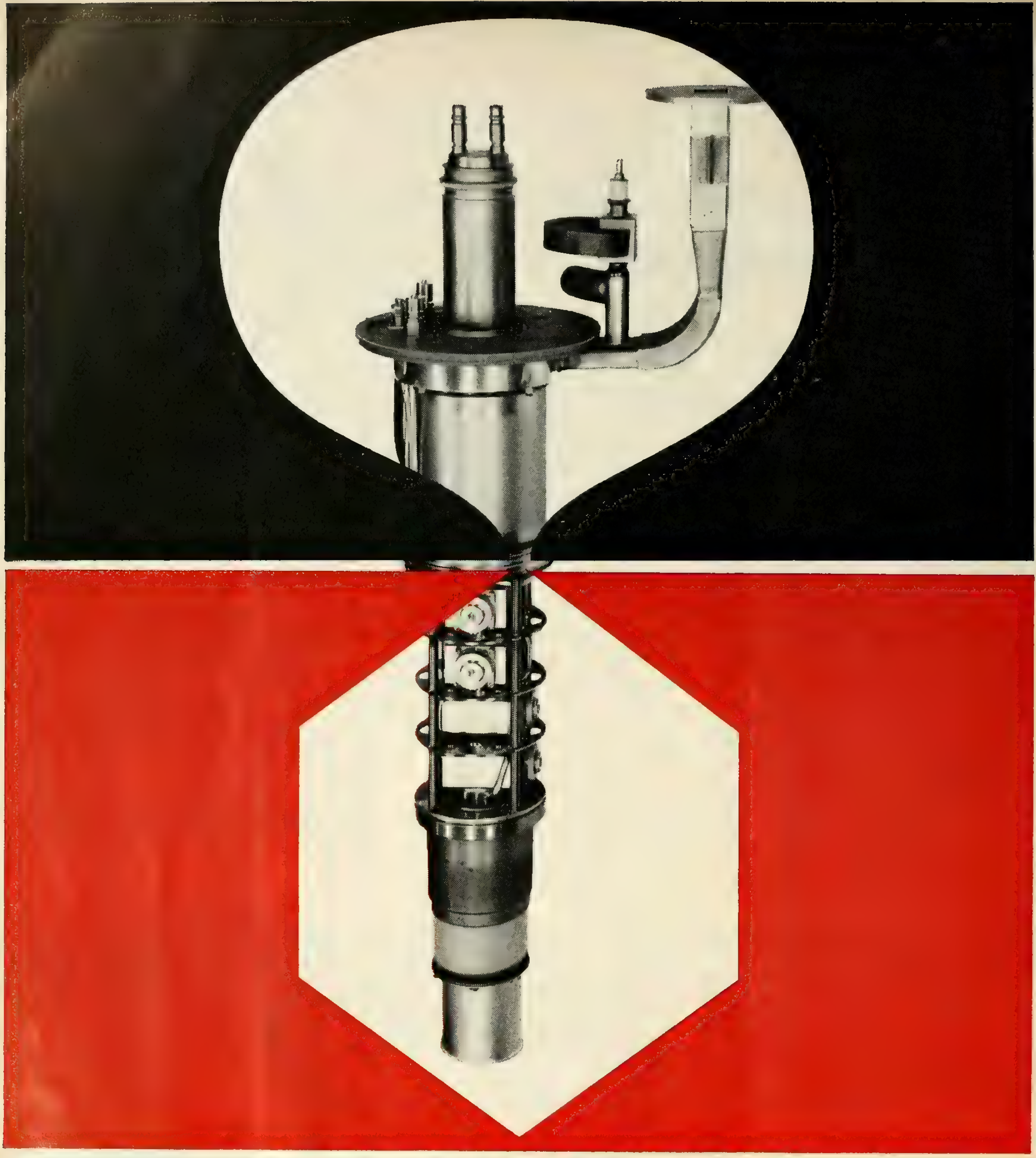

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Technical Countdown

ELECTRONICS

Plasma Diagnostic Probe Perfected

Scientists at General Electric's Radio Guidance Operation are testing a plasma diagnostic probe which shows promise as an instrument to measure electron density distribution in the flow field of a re-entering hypersonic vehicle. It also measures the electron temperature at the same point simultaneously. The ruby laser plasma probe can measure electron density distribution with a resolution of 1 cm^3. It uses a 0.30 joule, Q-Spoiled laser with a 1 cm. diameter beam and a pulse duration of 30 nanoseconds. The device does not disrupt or modify the flow field and has application to other plasma diagnostic requirements. The development was funded by the Air Force's Cambridge Research Labs.

Ultra-Thin Lead Wire Available

A smaller, lighter lead wire for aerospace and computer applications with fluorocarbon insulation thicknesses as low as 2 mils is being marketed by American Super-Temperature Wires, Inc., Winooski, Vt. Designated Ultra-Thin (TM) by the Haveg Industries, Inc. subsidiary, the wire is available in AWG sizes from 20 through 36, and in a variety of strandings.

More Radiation Test Data

Engineers from Hughes Aircraft Co.'s Nucleonics Div. reported to the IEEE on new test results using microelectronic devices in a transient nuclear radiation environment. Tests showed that hybrid thin-film circuits, even with the best high frequency transistors, are limited to maximum dose rates on the order of 10^7 r/sec. Tests on P-N junction field-effect transistors showed that most do not perform as well as the best high frequency bipolar transistors available. Tests on experimental thin-film insulated-gate field-effect transistors showed them to be unaffected by transient radiation dose rates of 10^8 r/sec.

MATERIALS

Glass Encapsulating Process Available

G. T. Schjeldahl Co. scientists have developed a sputtering technique that permits the deposition of quartz, Pyrex, soft glass or alumina without appreciably raising substrate temperature. Developed for use in encapsulating microelectronic circuits, coatings of up to 10^{-5} in. are now being routinely laid by the firm over flat areas of up to several square feet. The encapsulation, the firm claims, is flexible, shows high dielectric strength and is readily applied in production quantities.

Present Under Glass

Scientists from the R&D lab at Corning Glass Works, speaking in St. Louis this month at the IEEE Microelectronics Symposium, warned designers and producers of thin-film circuits to pay more attention to the substrates they choose and not succumb to the commonly held view that the substrate is not only electrically inert, but also has little or no effect on the film circuit elements. They report that although substrate-film interractions are almost always second-order effects, "they do indeed influence circuit properties." Special substrate glasses and glazed, high-thermal-conductivity ceramics appear to be the best suited for most applications. The glass experts stress that film and substrate material properties, surface smoothness, cleanliness and measurement factors must get increased attention.

Controlled Small Alumina Crystals Produced

Alumina ceramics approaching theoretical perfection in density and purity are being produced through a patented process by Reynolds Chemical Div. of Reynolds Metals Co. The new, low-soda crystals—RC-100 Series—have average grades as low as one micron. Key to the Reynolds process is a high-temperature calcining of alumina with coarser materials containing silica. Soda from the alumina reacts, combining with the silica, and is removed by screening. The crystals do not grow appreciably during the heating.

PROPULSION

High-Energy Solid Plant Started

Construction is under way on a new high-energy solid propellant plant at Thiokol Chemical's Wasatch Division near Brigham City, Utah. The facility will house both propellant mixing and motor loading equipment with an initial motor size limit of 20,000 lbs. propellant weight. The site is adjacent to the firm's R&D plant, where the raw materials will be processed. The high-energy plant will have automated equipment similar to that in other Thiokol solid propellants plants. Two mixers—a 150-gal. vertical Baker-Perkins and a smaller experimental unit—will be installed in the new facility. Completion date for the facility is this summer.

LEM Expulsion Tanks to Bell Aerosystems

Positive expulsion tanks for the Lunar Excursion Module will be designed and produced by Textron's Bell Aerosystems Co. under a $3.5-million contract from Grumman Aircraft Engineering Corp. The LEM tanks will be similar to those being built by Bell for the *Apollo* Command and Service modules. Flexible bladders will be used inside metal tanks to expel fuel and oxidizers as needed. Bell has developed a family of bladder materials resistant to the major reaction-control propellants.

SPACE MEDICINE

Biotelemetering Facility Established

A new laboratory, which can receive and transmit biomedical data from orbiting satellites is being constructed at the School of Aerospace Medicine, Brooks AFB, Texas. The "Telemetry Data Analysis Science Laboratory," to be completed in August, is being built by Darragh and Lyda Construction Co. of San Antonio. It is expected to play an important part in the *Manned Orbiting Laboratory*.

Steam Concept Interests Air Force

ASTEC may be reoriented to accept water as working fluid; solar collectors to get increased emphasis for next 3 years

by William Beller

THE AIR FORCE has discovered that steam can be used for generating space power. Embarrassed at the belated confirmation of what powerplant engineers have been telling them for years, Air Force officers responsible for the ASTEC (Advanced Solar Turbo Electric Concept) space-power program are considering what to do next.

Until recently, the Air Force was sold on spending a lot of time and money developing a 15-kw solar dynamic space-power system based on the exotic metal rubidium as the working fluid. Then, late last month, contractors working on Air Force space-power programs received a communication from the Research and Technology Division of the Air Force Systems Command at Wright-Patterson AFB, Ohio.

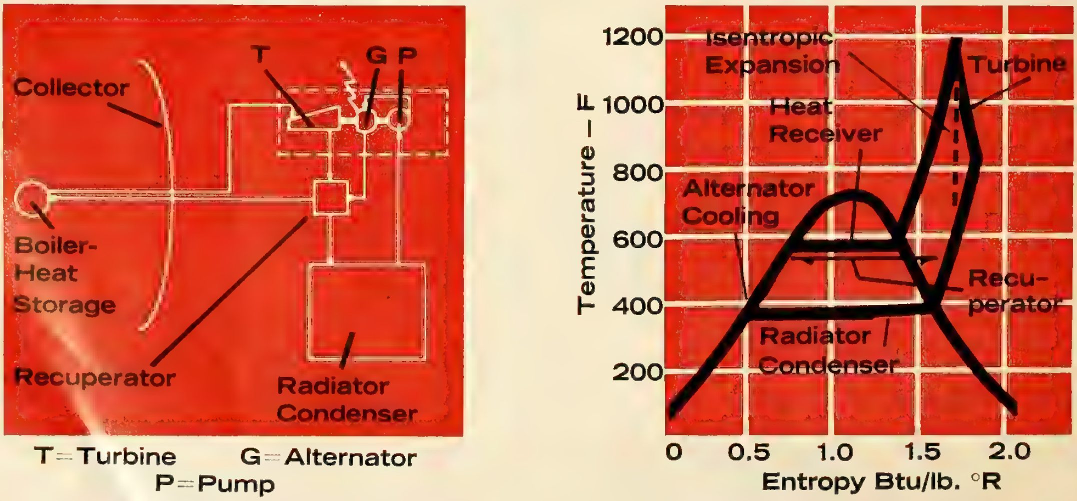
Their studies indicate, the letter said, that "the use of a metallic petal collector and a Rankine cycle with water as the working fluid (is) the proper choice to provide low development risk consistent with a 1968-1970 availability date (for solar dynamic space power)."

Air Force investigators freely admitted that their finding was unexpected: "With regard to the performance of this concept, our analyses showed that it is surprisingly good relative to other concepts."

The Air Force Aero Propulsion Laboratory of the R&T Div. is trying to produce by early summer a preliminary detailed technical report covering performance evaluation of the steam cycle and other cycle and working-fluid combinations. This will include the Rankine, Brayton and Stirling cycles. The formal report is scheduled for release the first of October.

At the time the contractors found out about the Air Force's strong interest in steam, they also were told that a decision had been made to concentrate on developing solar collectors for the solar dynamic system. MISSILES AND ROCKETS learned that the service considers this aspect the toughest part of the problem. Given a "realistic funding level," it expects to study collector development intensively for about the next three years.

The service expressed in its letter to contractors the problem of deciding which tune to dance to: "During this time period, an assessment of possible conversion schemes will be continued such that, at a later date, when the con-



LEFT: Schematic of 20-kwe steam powerplant for space. RIGHT: Typical temperature-entropy diagram.

version machinery is added to the program, the scheme most commensurate with the guidelines in effect at that time will be pursued."

- **Background**—It is not surprising that the R&D Division is apprehensive about going out on a limb. Its hesitation stems from 1960, when the ASTEC contract was awarded to Sundstrand Aviation. The Air Force asked for an exploratory program directed toward getting a breadboard of an advanced solar dynamic system with a design point at 15 kw, but a technology suitable for the 7 to 25-kw range.

Since no flight date was specified, and the main criterion was to get the system with the best working fluid and lowest specific weight, Sundstrand decided upon rubidium. This was a high-temperature system, which simultaneously resulted in a relatively small radiator and high Carnot efficiency.

Another factor favoring the rubidium system was that existing micrometeoroid data pointed to relatively heavy radiator cladding for radiation protection. This meant that a lower-temperature system would suffer not only from the demand for a larger radiator, but also from the need to clad this larger area to protect it against micrometeoroid puncture.

The micrometeoroid hazard had been based on the work of R. L. Bjork, published by the Rand Corp. in 1960. Then, in January, 1963, Fred L. Whipple gave a paper, "On Meteoroids and Penetration," to the American Astronautical Society, indicating that the Bjork data were too conservative. This meant that less cladding would be needed to prevent meteoroid penetration of space radiators and, consequently, relatively low-temperature systems such as steam or organic fluids could be competitive.

At the beginning of the current fiscal year, the Air Force decided to move ASTEC from exploratory development to advanced development. At this point, the Office of the Director, Defense research and Engineering interposed a program-definition phase. Accent was to be on the energy collectors as opposed to the energy conversion subsystem. Nevertheless, Air Force headquarters told its Wright Field Laboratory that it had an application in mind for ASTEC and the system should be readied for the 1968-1970 time period.

In March, Wright Field came up with its answer: the Rankine cycle is the best cycle to use. Steam is the best working fluid because it is competitive with other working fluids and also has a technology based on decades of work in stationary steam powerplants. A 15-kw solar dynamic system can therefore be built to meet the 1968-1970 development deadline.

To their chagrin, the Wright Field engineers were told by headquarters: 1) There's no mission for ASTEC; 2) Therefore, the 1968-1970 target date no longer holds; 3) Continue your work on collectors.

Summing up the situation, one Air Force official said, "It's all very confusing."

- **Astra's work**—A small research organization in Raleigh, N.C., has been trying to persuade government agencies for years that steam is one of the answers to the space power problem. The National Aeronautics and Space Administration was first to recognize the merit of the proposal of Astra, Inc., when it awarded the company a study contract to look into the concept. Later, engineers at the Lewis Research Center verified the findings of Astra.

Astra describes four possible solar dynamic powerplants based on the steam cycle. All are rated at 20-kw electrical output. The first represents a "do-it-now" approach, based upon conservative assumptions; it shows a system specific weight of 90 lb./kwe. This weight, however, does not include the mounting hardware and orientation equipment that Sundstrand includes in its 15-kwe rubidium system. The Sundstrand system is designed for about 70 lb./kwe.

Astra suggests that subsequent development of the steam space powerplant will push its specific weight down to 65 lb./kwe, 60 lb./kwe, and "ultimately," 47 lb./kwe.

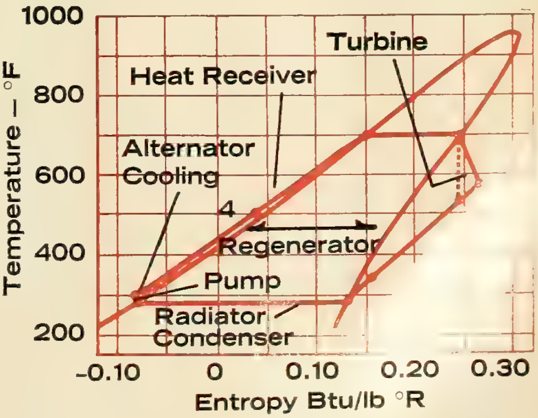
A diagram and thermodynamic cycle of the steam system are shown here. The heat source, a solar collector with energy storage for night operation, supplies superheated steam at 1,200°F to a turbine, which drives an electric generator. After expansion through the turbine, the residual superheat is removed by a recuperator, and saturated vapor enters the condenser-radiator, where it is condensed and slightly subcooled. The water is then circulated through the generator (for cooling) and preheated in the recuperator before being returned to the energy source to be boiled and superheated. Note that with the exception of the radiator, the system consists of a single loop.

The turbine is a conventional several-stage partial-admission turbine using condensate-lubricated graphite bearings. The possibility of using a reciprocating steam engine also has been considered. The pump and recuperator are of standard design and the generator could be a compact, high-efficiency solid-rotor type—although more conventional designs may be used with some degradation inefficiency. The radiator, because of its low operating temperature, may be constructed of aluminum. The approach of an established beryllium alloy technology promises reduced radiator and structure weights.

- **Organic fluids in space**—For power levels of 1.5-kwe, Sundstrand has turned from the alkali metals to the organic liquid biphenyl, used in a Rankine cycle for a space dynamic system. An important characteristic of biphenyl is the positive slope of the vapor line on the temperature-entropy diagram. This is opposite to that of many other fluids such as steam and liquid metals.

Isentropic expansion processes with biphenyl extend into drier regions, instead of approaching the saturation line as is the case with steam. As a result, superheat is not required prior to expansion of biphenyl vapor.

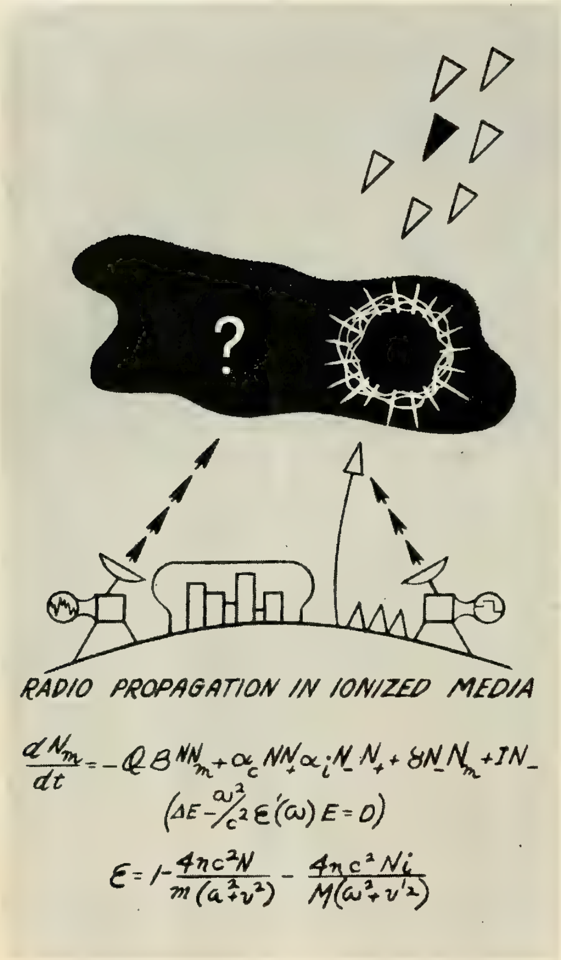
Clearly, a way is now open to exploit familiar fluids in space powerplants, solar and nuclear. One of the unanswered questions raised by industry as well as by the Air Force itself: "What are we waiting for now?" ■



TEMPERATURE-ENTROPY diagram for a 1.5 kwe Rankine cycle space system using biphenyl, an organic working fluid.

ENGINEERS/SCIENTISTS

WORK ON PROBLEMS LIKE THIS...


?
RADIO PROPAGATION IN IONIZED MEDIA
$\frac{dN_m}{dt} = -QB^{NN}_m + \alpha_c NN_+ \alpha_i N_- N_+ + \gamma N_- N_m + IN_-$
$(\Delta E - \frac{\omega^2}{c^2} \epsilon'(\omega) E = 0)$
$\epsilon = 1 - \frac{4\pi c^2 N}{m(a^2 + v^2)} - \frac{4\pi c^2 N_i}{M(\omega^2 + v'^2)}$

WITH ASSOCIATES LIKE THESE...

Mr. W. H. Thiel (left) is presently Technical Assistant to the Manager of Advance Missile Engineering. In the past 20 years he has acquired experience in application of high explosives to destruct systems, electrochemistry, thermodynamic propulsion analyses for offensive and defensive missile systems, and basic research in nuclear physics at Argonne National Laboratory. Mr. Thiel has an M.S. in Chemistry from the University of Michigan and is a graduate of the Oak Ridge School of Reactor Technology.

Mr. Nigel Thomas (right) is a member of the Systems Analysis Branch, Advance Missile Technology, and is currently working on the relation of nuclear weapons effects to missile defense systems. After carrying out research work on combustion physics and high-temperature dissociation at Imperial College, London, and Princeton University, Mr. Thomas worked on hypersonic boundary-layer transition phenomena at Aerophysics Development Corporation. Prior to joining Douglas, he carried out work on directed weapon effects at high altitude with Aerojet-General Corporation.

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120-in. Boosts Argument for Solids

UTC says clusters can give up to 15 million lbs. of thrust with high reliability; switchover still possible in Saturn V

by Robert Lindsey

SUNNYVALE, CALIF.—Development of the 120-in. solid rocket motor for the *Titan III-C* booster is threatening to trigger a new round in the solid vs. liquid debate.

For the first time, a large solid motor with the reliability, experience and cost advantages of a major development effort and substantial Air Force flight testing will be in position to compete with large liquid motors.

United Technology Center here, contractor for the solid motor "stage zero" of the *Titan III-C*, has made extensive studies of the rocket's potential as a standard "power unit" and asserts clusters of 120-in. motors can be built with lift-off thrust up to 15 million pounds while maintaining reliability equal to or better than a single motor.

Some industry leaders had suggested reliability must necessarily go down with each addition to a cluster.

Not only will the USAF-624A program produce an Administration-favored "building block" system capable of assembly into first- and second-stage vehicles of many thrust and payload combinations, but the motor will also mature midway in development of the *Saturn V*.

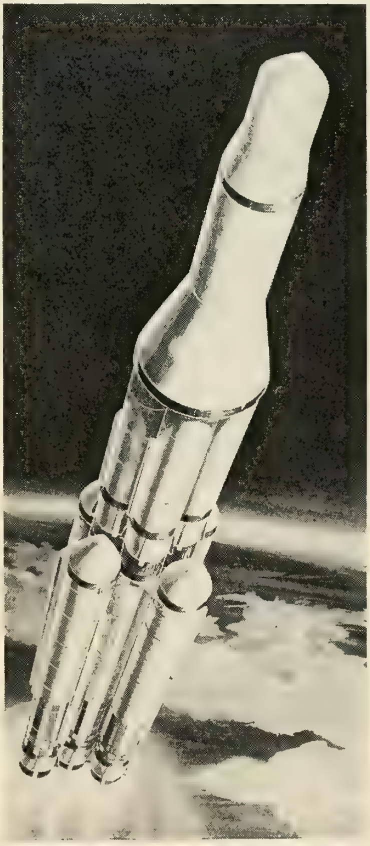
If this program encounters trouble, solids conceivably could shoulder their way in—either in clusters, as a replacement for the first stage of *Saturn V* or, more likely, as strap-on boosters for thrust augmentation.

Whether major changes would be introduced in the lunar landing program so far downstream and whether political factors—NASA's huge investment in liquids, for example—would allow solids to play a major role in Project *Apollo* is debatable.

● **Sub for Saturn V?**—But the availability of solids for relatively low-cost thrust augmentation could be attractive if the *Saturn V* runs into payload deficiencies.

UTC, in recent presentations to NASA and the vehicle contractors involved, has said payload capabilities of the *Saturn 1B* and *Saturn V* can be increased by as much as 80%—at a declining cost per-pound-in-orbit—by use of 120-in. strap-on solids.

In reviewing the United Aircraft Corp. division's research on potential applications for the 120-in. motor, Division President Barnet R. Adelman said clustered 120- or 156-in. boosters could perform comparable missions "substantially" cheaper than either single-chamber or clustered liquid engines. And since each solid motor in a cluster operates virtually independently of the others, unlike clusters of liquid engines, reliability is substantially higher.



UTC CONCEPT shown in artist's drawing calls for two stages of clustered 120-in. motors with Titan-type liquid third stage, giving 106,000-lb. payload in 300-mi. orbit.

Adelman said UTC feels clustering of 120- and 156-in. motors will be the next step in big solid technology rather than exploitation of the 260-in motor. Technology of the large motor is far from developed, especially in the areas of nozzle design, grain configuration and fabrication of flight hardware. Also, logistics of such a large vehicle will always be a substantial problem, he said.

Until 260-in. motor technology is proven, Adelman said, the proven reliability of the 120-in. motor—established in about 50 static and flight tests in the *Titan III* program—will give it an unbeatable edge.

And by the time 260-in. technology is established, Adelman predicts, it will have been overtaken by hybrid rockets. "I predict the first operational 260-in. motor will be a hybrid . . . and I'll also predict that by the time these motors are needed, they'll be used in clusters," he said.

● **Applications for 120's**—UTC has studied applications for the 120-in. motor ranging from use as a follow-on to *Minuteman,* to use in clusters of up 15 motors with lift-off thrust of more than 15 million pounds, capable of injecting about 200,000 pounds into a 300-mile orbit, depending upon which upper stages are used. Use of clustered 120-in. second-stage vehicles—attractive for quick-reaction requirements of military operations—are also receiving close scrutiny.

Adelman said UTC's studies are applicable also to 156-in. motors, for the

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technology is essentially identical; the 120-in. width for *Titan III-C* was selected essentially because that is the diameter of the *Titan II* core.

● **Early problems solved**—Adelman said two of the principal problems originally foreseen in using clustered solid rockets were achieving simultaneous ignition of all motors and simultaneous burn-out. UTC has studied these and other problems in 15 tests of small clustered rockets with thrust levels up to 60,000 pounds.

The problem of achieving simultaneous burn-out was not as serious as envisioned. In all UTC tests of big solids—11 to date—burn-out has been within ±1% of that forecast. With experience of the *Titan III* program, it should be even more predictable.

Assuming simultaneous ignition, variations of burn-out should be easily within the range of correction of the system's thrust vector control (TVC) system, UTC engineers report. Thrust termination is provided in the *Titan III-C* motors. Studies are under way here now to determine the necessity of termination in clustered systems.

In the area of structures for clusters of large motors, UTC analyzed the problem using its *Titan III-C* experience—it is essentially a clustered booster—and concluded the weight of cluster structure should have very small effect on mass fraction.

The grain configuration of clustered 120-in. motors would be essentially similar to that of the *Titan III-C* motor, UTC engineers said. At most, only a small modification of the thrust-time curve would be necessary to assure that maximum acceleration forces at burn-out of an eight-motor cluster would be no more than 6-8 g's—well within limitations for manned operations.

● **Clustering prejudice overcome**—In the past, explained Dr. Richard Smith, who heads UTC's cluster studies, many propulsion engineers have written off clusters of big solid rockets because they felt each additional motor degrades reliability.

But Smith said this approach makes the mistake of multiplying the individual reliability factor of each motor to determine total system reliability. Instead of looking at reliability of a clustered rocket as the product of individual motors, Smith emphasized, it should be examined on a systems basis. An entirely different reliability picture emerges, he said.

Smith said that with redundancy of certain components, use of a common ignition system for all motors and a slight (three per cent) intentional reduction of the system's payload capability, a clustered rocket can have reliability equivalent to that of an individual motor.

Also, reliability of the cluster can exceed that of a single, much larger motor as powerful as that of the cluster, unless the single larger motor has had testing experience equivalent to that of each smaller motor in the cluster.

To illustrate, Smith described one propulsion system examined by UTC—a three-stage design with a cluster of eight seven-segment 120-in. motors as first stage, a second stage of four four-segment 120-in. motors and a third stage utilizing the liquid engine of the *Titan II* first stage.

Nominally, this vehicle has a payload capability of 110,000 pounds in a 300-mile orbit. But it was derated to 106,000 pounds as a cushion in case of motor component failures that would reduce the payload but not abort the mission.

(In a parallel analysis, a design was studied using eight five-segment 156-in. motors as first stage; a four two-segment 156-in. cluster as second stage; and a storable liquid third stage. Its nominal payload would be 330,000 pounds, derated to 320,000.)

● **Determining reliability**—For purposes of the study, the 120-in. motor arbitrarily was assigned a reliability factor of 0.96, which UTC says is "well below" the actual figure. Within this factor, the relative failure rate of major components of solid rockets were analyzed, Smith said. "If it is assumed the frequency of failures of the propellant, case and insulation sub-system is one, then ignition failure is assigned the frequency of three, nozzle failure five times and TVC failure 20 times . . . the TVC system has the only moving parts," he said.

The analysis produced this expression of reliability:

Propellant, case and insulation	0.9985
Ignition	0.9956
Nozzle	0.9926
Thrust vector control system	0.9710

The traditional way to judge the reliability of a cluster of eight engines uses the Product Rule of Statistics: $0.96^8 = 0.71$—an intolerable figure. But, Smith said, this approach is invalid because it assumes each motor functions independently and every component failure leads to destruction of the cluster.

A different answer comes from a systems approach, he said. Only in the first case (propellant, case and insulation) must the Product Rule apply, because it is the only category in which an individual failure destroys the cluster. No reliability is possible. Hence, the reliability is $0.09985^8 = 0.09880$.

● **Ignition reliability**—For the ignition system, UTC said the best approach is not to use individual airborne ignitors—the standard design approach—but to design around unreliability and develop a pad-mounted ignition system that operates on all motors at once.

Two systems were built and tested under Air Force contract, one a hypergolic ignitor that sprays chlorine triflouride into the aft of each engine from a common pressurized tank and one using aft-end rocket motors.

Although both systems were acceptable, Smith said UTC favors the small rocket system because of both electrical and mechanical redundancy.

In this design, the nozzles of eight small rockets are located beneath each nozzle of the clustered motors. Normally, a squib would ignite each of the small rockets simultaneously, and their exhaust gases would ignite the main rockets.

But in the UTC design, if one igniter fails, a hot-gas manifold linking all ignitors would shoot gases into the grain of the non-working motor, assuring virtually simultaneous ignition. In one test, an electrical igniter squib was deliberately removed, and the motor was ignited via the hot gas manifold only 50 milliseconds late—an acceptable delay.

With such a system, Smith argues, much of the unreliability risk of a clustered motor vanished. "The ground-based system, once actuated, has little unreliability in distributing ignition to all motors of a cluster. If the basic ignition circuits or mechanisms do not function, no motors are ignited."

With this system, Smith said, a reliability rating of 0.9999 can be postulated, far higher than if each motor had its own igniter.

Nozzle reliability in a cluster is a product of many considerations.

By de-rating the payload three per cent, Smith said, it is possible for the vehicle to accomplish its mission if one of the eight nozzles fails downstream at the throat during burning time.

If a nozzle failure ejects the nozzle's entire throat, the cluster will not be destroyed, and abort would not be necessary. But the payload would be degraded greater than 10% by the loss of impulse and the necessity for carrying unburned propellant. Basing his estimate on past experience and the deliberate de-rating, Smith assigns a reliability figure of 0.9817 for the eight nozzles in the system.

- **TVC considerations**—In considering the TVC system reliability, cluster designers would have a bonus.

While the *Titan III-C* motor's TVC system is capable of an angular deflection of more than five degrees, UTC studies indicate deflection of only three degrees would be required for guidance of a large cluster of motors.

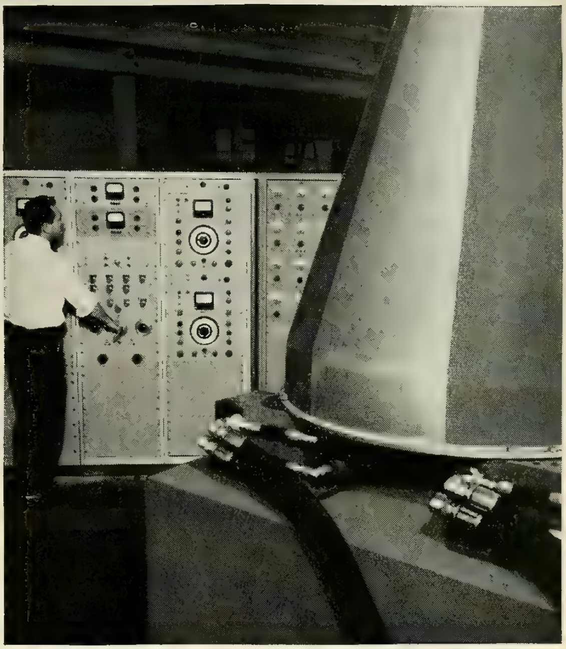
From a cluster standpoint, TVC systems in only five of the eight motors can be operative and still maintain necessary side force. A very high degree of redundancy exists within the liquid injection TVC system, and this results in high reliability in cluster applications. UTC computes that for the cluster of eight motors, at least 20 of the 32 quadrants must operate, with no more than one injector valve failing per quadrant. Smith postulates a TVC system reliability of at least 0.988, and he calls this "very conservative."

Thus, by looking at clustered boosters from a systems basis, one gets this reliability picture:

Propellant, case and insulation	0.9880
Ignition	0.9999
Nozzle	0.9817
TVC system	0.9880
Net reliability of cluster	0.9560

The value of 0.956, almost equivalent to the single motor reliability of 0.96, is significantly greater than the 0.721 figure which might be attributed to clusters. ■

MB TEST EQUIPMENT NEWS



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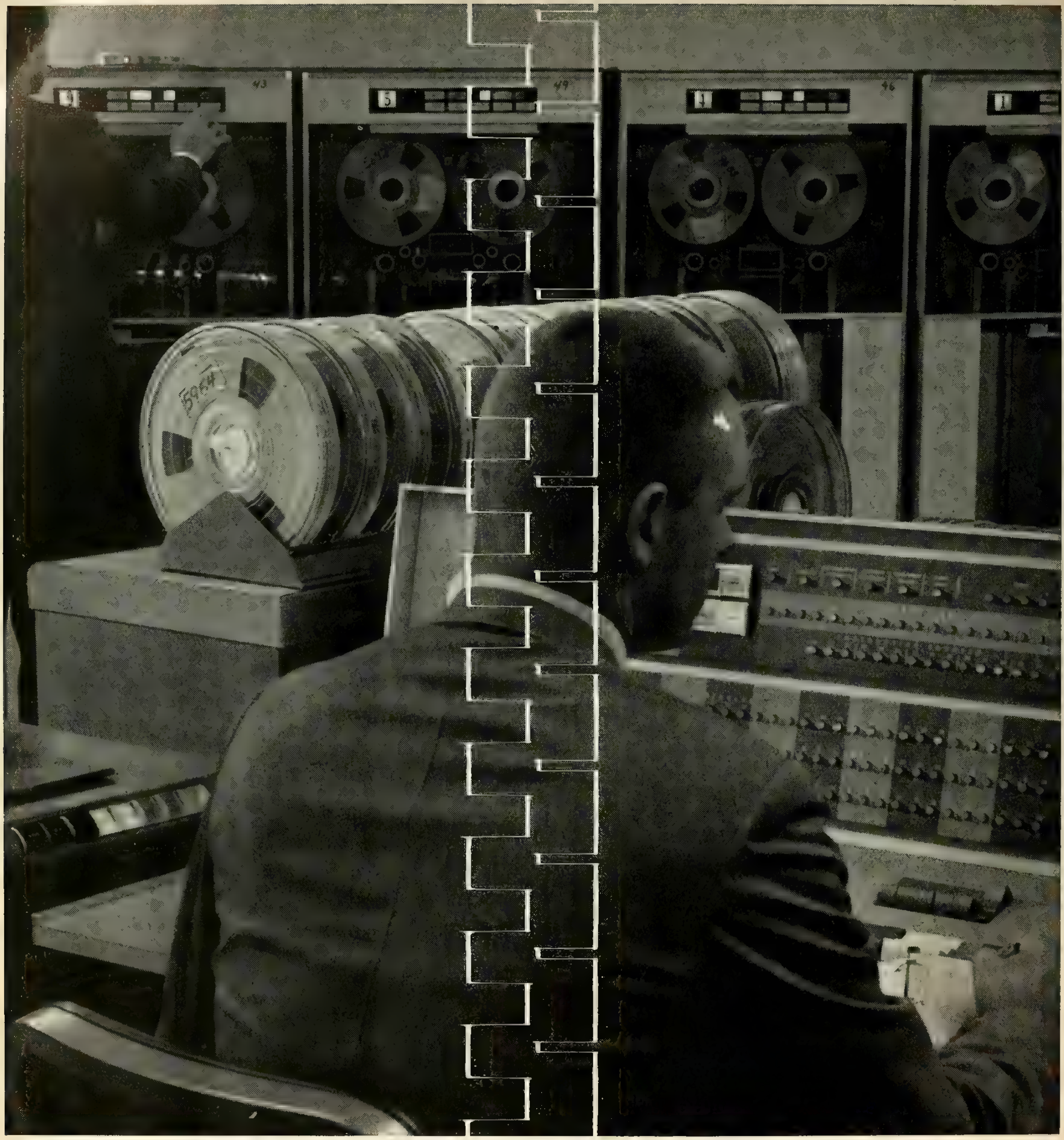

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SERT Power Requirement Straining Solid-State Technology

PHOENIX, ARIZ.—Power requirements for the *Space Electric Rocket Test (SERT)* have proved a difficult load for solid-state electronics, but NASA still expects to launch two ion engines in a *Blue Scout* payload in the third quarter of this year.

Delegates to the International Aerospace and Electro-Technology Conference were told here last week that the *SERT* program is aiming for 50 minutes of ion engine operation, at altitudes above 200 n. mi., in ballistic flights.

- **Phoenix conference**—The Institute of Electrical and Electronic Engineers 1964 International Aerospace Conference drew more than 1,400 scientists and engineers from the U.S. and Europe. Three invited Soviet scientists failed to secure last-minute release from Air Force security restrictions despite an appeal from conference chairman A. J. Wesolowski. The largest foreign representation was from France, registration showed.

The four-day technical program (April 20-23) provided a small exhibition (35 exhibits) and 120 technical papers. Overall scope of the 27 technical sessions was the presentation and discussion of the latest advances in the application of electricity and electronics in space systems, including energy conversion techniques and systems.

Keynote luncheon speaker was Dr. Richard B. Kershner, supervisor of the Space Development Div., Applied Physics Laboratory, Johns Hopkins University. Dr. Kershner, long associated with the Navy's missile and satellite R&D programs, traced the history of reliability requirements in flight electronic systems from the days of the German *V-2's* to the present.

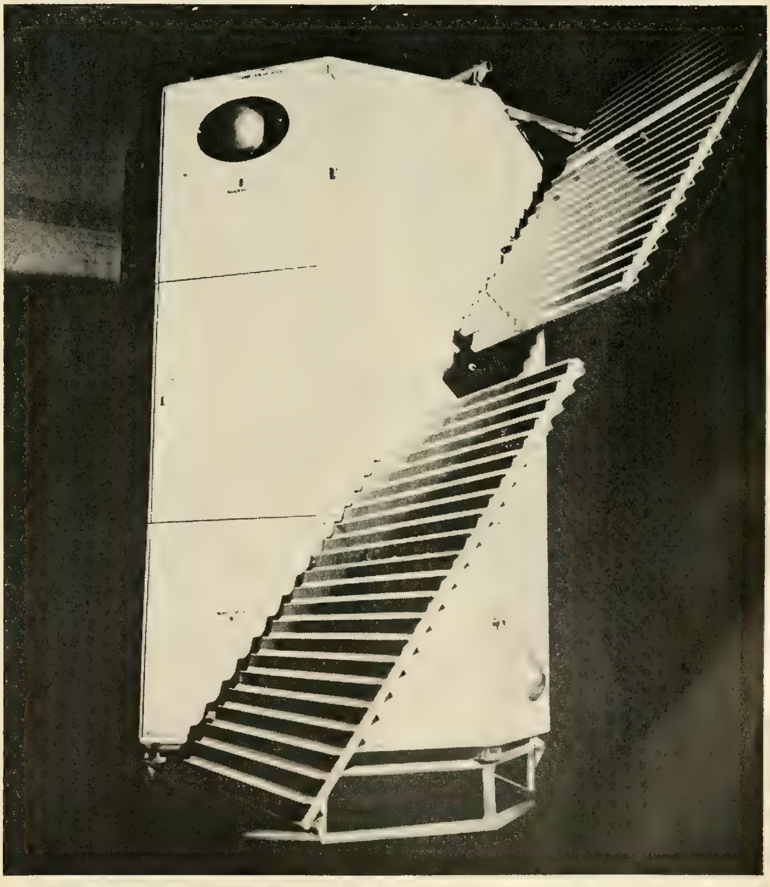
A 75 to 85% reliability figure for military missiles, he said, possibly represents the desired optimum for maximum cost-effectiveness.

The very stringent reliabilities required in spacecraft, however, result from the need for long-time operation and the high cost of launch vehicles. Near 100% reliability is being achieved, he asserted, by over-design and rigid repetitive testing. In general, he pointed out, "it is easier to obtain long operating life in space systems than in ground systems."

One to three-year operation for space systems is now practical; five-year operation will be possible soon with the proper application of circuit redundancy in system design.

- **SERT**—The 350-lb. *SERT* payload package will carry two thrustors, mounted to produce opposing forces about the spin axis. An initial spin stabilization of about 100 rpm will be given to the package and change in spin speed will provide a basis for computing ion thrust.

One thrustor, developed at NASA's Lewis Research Center, employs electron bombardment of mercury vapor to produce ions and is powered by a unit developed by Thompson Ramo Wooldridge Electromechanical Div. The



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other, developed by Hughes Aircraft Co., employs contact ionization of cesium vapor passing through hot porous tungsten.

Describing NASA work in ion thrustors, J. T. Kotnik and B. C. Sater said that under certain conditions, ion thrustors drew exceedingly high electrode currents. This meant that rapid shutdown had to be incorporated to improve the reliability of the high-voltage inverters.

Also, destructive voltage transients created by arcing between ion thrustor electrodes were coupled into the inverter and control electronics. Preventive measures included use of shunting capacitances, Zener diodes and better electrostatic screening.

Studies under way show that simultaneous station-keeping and attitude control of a synchronous satellite by means of a Hughes-type propulsion system would require an inverter supplying a peak power of 1,110 watts. A one-axis system built by Hughes Research Labs and being evaluated at Lewis consists of a pod containing three thrustors, controls, a propellant system and a power supply. Within the pod are two strip-beam 2.2-millinewton thrustors for attitude control and an annular beam 6.7-millinewton thrustor for station keeping.

Three-kilowatt ion thrustors are under development by Hughes and by Electro-Optical Systems, Inc. Kotnik and Sater consider that 30 kw represents the limit in size for ion thrustors.

- **Control of OAO**—Because *Orbiting Astronomical Observatory* missions call for a wide range of spacecraft maneuvers followed by accurate stabilization, the spacecraft carries a sophisticated combination of inertial reaction wheels, magnetic stabilization and momentum dumping, and gas jets.

In one mode, the spacecraft will scan the sky; in another, it will point in one direction for up to 150 minutes. In the fine pointing mode, the target accuracy is 0.1 second of arc.

According to R. G. Rennie, Grumman Aircraft Engineering Corp., and H. H. Chanowitz, Dalmo Victor Co., the *OAO* magnetic system uses the Earth's magnetic field as a spatial lever arm, either for transference of accumulated angular momentum in the inertia wheels or for controlling spacecraft orientation directly.

They say that it is now a primary system with low-thrust gas jets acting as a backup. A three-axis flux-gate magnetometer measures the magnetic field vector, and three ion-core electromagnets develop the correcting torque vector.

The complete magnetic control system, including the electronics that process the magnetometer output, weighs 26.6 lbs.—one-fifth the weight of a gas jet system, say Rennie and Chanowitz. A power of 5.8 watts is required.

A second-generation system is being developed with a weight of 11.6 lbs. and a power consumption of 4.0 watts.

After insertion by an *Atlas-Agena D*, the spacecraft will be initially stabilized by rate gyros and high-thrust gas jets to lock onto the Sun. A biased rate gyro will then roll the vehicle in search of a preselected stellar reference —any one of 31 second-magnitude guide stars. Three mutually perpendicular, coarse inertia wheels are used, open loop, to slew the vehicle about each axis in turn, while star trackers continue to track the guide star.

Once target pointing is achieved, the system switches to three fine inertia wheels, controlled by an average error signal from the star tracker.

Gravitational, magnetic, aerodynamic and radiation torques will give a resultant torque that varies sinusoidally about a steady value. The sinusoidal torque is easily countered by the inertia wheels, but the steady torque causes wheel speed to build up continuously. To prevent this, the magnetic unloading system extracts energy from the wheels and clamps their speed below 100 rpm.

Typical slewing requirements for the *OAO* are two degrees in 30 seconds and 30 degrees in three minutes. Describing the design of the reaction wheel system, L. Demarinis and H. Huttenlocher, Jr., Grumman Aircraft, said that a slewing duty cycle of 50 minutes per day was expected. Power consumption would amount to about 2.5 watts, averaged over a day.

- **SNAP-3 to IMP**—The technological advances resulting from the evolution of space isotopic power generators, SNAP-3, -9A and -11, have been combined in the design of the nuclear auxiliary power units for the *IMP (Interplanetary Monitoring Probe).*

The design for such a system is now complete and prototypes are in production, Martin Co. Nuclear Div. engineers J. G. Morse and C. R. Fink disclosed at the conference. Development of the system began in February, 1963, with the award to Martin of an R&D contract from the Atomic Energy Commission. In effect, it anticipated NASA's requirements for the *IMP* series spacecraft.

Specifications met in the design for *IMP*, the authors disclosed, include: a three-year design life, 23.6 watts (E) at fueling and 22 watts (E) at end of life (4.75v and 4.65 amps). The design includes use of modularized thermoelectric couples. Each is a right circular cylinder with two longitudinal fins measuring $5\frac{5}{16}$-in. dia. by 9¾ in. long. The heat source is plutonium (PU-238) with a half-life of 86.4 years. ■

Graphite Masking Technique Developed for Thin-Film Circuits

by Michael Getler

St. Louis—Engineers at the U.S. Naval Avionics Facility (NAFI) at Indianapolis, Ind., are now setting up for pilot production runs of passive thin-film circuits using newly developed graphite masks for film deposition.

A report on the new masking technique, presented by NAFI's Guy Robert Stutzman at the IEEE's Third Annual Microelectronics Symposium held here this month, drew considerable post-session attention from several major system companies. Stutzman is chief of NAFI's Advanced Manufacturing Techniques Branch.

The new masking technique has evolved at NAFI, Stutzman told Missiles and Rockets, primarily through a much broader study assigned to the facility in October, 1962, by the Navy's Bureau of Weapons. The object was to evaluate in-line thin-film production techniques to improve overall circuit design and extend their use into a wider number of Navy weapon systems.

NAFI engineers pursued a number of techniques, hitting upon the graphite masks about nine months ago. The masking technique has now reportedly been released to manufacturing operation shops at NAFI, and within the next year the pilot line will produce 100 different thin-film circuits that will require at least 1,000 graphite masks, each of different design.

Stutzman sees the use of masks made from newly developed high-purity, high-density graphite, capable of being machined on programmed high-speed tape-controlled milling machines, as the way to break the bottleneck hampering rapid transition of circuitry from design stage to hardware.

- **Technique's advantages**—Stutzman told M/R he estimates the technique, when fully refined, would lead to time and cost savings in the mask-making process of 95% in comparison to more commonly used approaches. It would also expedite the time in which new circuitry can be built and evaluated. Most masks now are produced by arc erosion or chemical etching and photo etching processes.

The graphite being used in the NAFI program is being supplied by Ling-Temco-Vought, Inc., which NAFI engineers say is the only source of the extremely small (0.31 microns) particle size graphite used in the process.

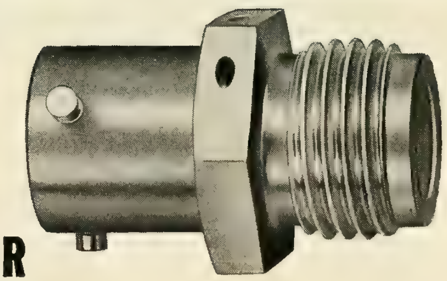
The LTV material has evolved from earlier re-entry body work done by the firm, possibly on the *Dyna-Soar (X-20)* program. Total impurities of the graphite can be reduced to five parts per million, according to Stutzman, who adds that the high-purity characteristics could become very important in the future for attempts at deposition of thin-film active elements upon the passive networks.

Stutzman, who terms the development process for the very-high-density graphite "a major technological breakthrough," also notes several other advantages for the technique.

Perhaps most important is the material's stability in very high temperatures which allows it to maintain its flatness during temperature changes in the deposition cycle and virtually removes distortive effects on the mask due to thermal cycling.

Stutzman told M/R that tests have been conducted with the graphite masks in a vacuum furnace showing no distortion at temperatures to 2,500°F, substantially above normal deposition temperatures. This allows the circuit designer to use thin cantilever sections without danger of excessive distortion.

The graphite supplied by LTV is delivered in ¼-in.-thick blocks with the mask area machined out to a 50-mil thickness where the actual circuit pattern will be cut. This leaves an integral ¼-in.-thick frame around the actual mask area, which improves structural strength and eliminates the prob-



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lem of machining separate frame and connecting parts.

- **Machining is easy**—Commenting upon the "excellent machinability and definition" of the graphite and the lines cut into it, Stutzman reports that with the current precision cutting tool used (a ground 30° cone) the very small particle size graphite "powders away," leaving no burrs or chip-type residue as may be found with machining metal. He also notes that machining produces no known stresses in the graphite structure that might tend to distort and bow the membrane in metal masks.

Line widths with current cutting tool equipments are limited to about a five-mil minimum, says Stutzman, though these widths can be controlled to ±0.0002-in. over the entire pattern. Stutzman predicts, however, that five-tenths-mil line widths will be achieved with graphite with good definition using electron beam techniques.

Stutzman told M/R that NAFI expects to have an electron beam device in-house in three months. Some machining experiments have already been conducted at the facility using electron beam and graphite. Machining residue will be evaporated with electron beam use.

In reporting upon the evolution of the BuWeps program, Stutzman told the IEEE audience that first masks used on the machine were glass, available only from one source, used a proprietary process, and cost $500 each. NAFI attempted to make thin stainless-steel masks by chemical etch, which wound up costing $800 each. The process also caused distortion that increased with use so that intimate contact with the substrate could not be maintained during deposition.

Thin-film panels for an experimental computer were produced using Invar masks machined by arc erosion. These cost $1,000 each, according to NAFI.

The cost of the graphite mask, including preparation of the punched tape, is estimated to be $20 per mask. "Once we have the tape," Stutzman told M/R, "we can produce a single mask pattern for $12.50."

NAFI plans to carry computer control and use data storage equipment even further to cut production time in the future.

Engineers are studying possibilities for completely eliminating the need for circuit layout drawings before actual machining. Necessary circuit information, according to Stutzman, would be fed in tabulated form to the computer, which would automatically locate, on a predetermined-size substrate, the resistors, capacitors, terminations, and conductors. "A tape for automatic graphite machining is then the resultant product of the computer," he reports. ■

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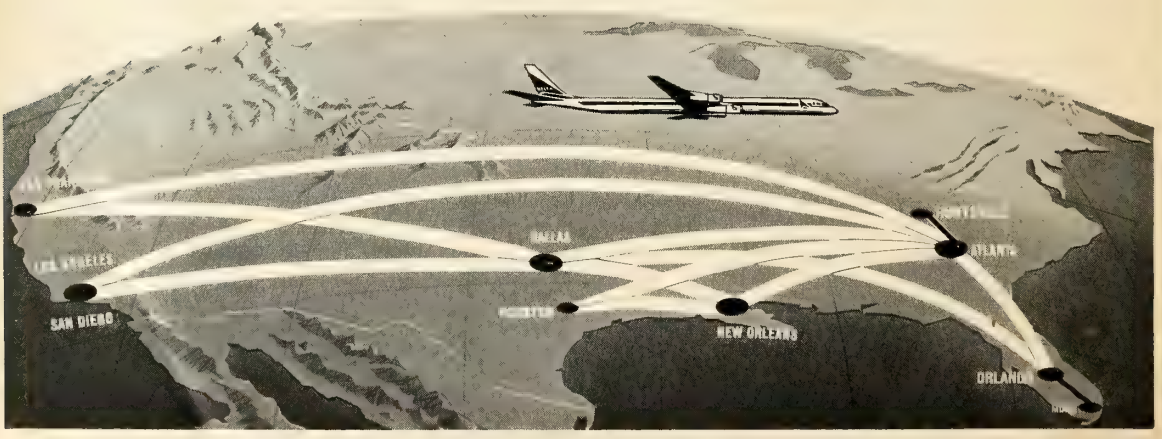

Mergers and Acquisitions

Donald G. Benner, general manager of Midwest Circuits, Inc., Minneapolis, Minn., has purchased all stock of that company. Midwest Circuits, founded in 1957 as Fabri-Tek Circuits, makes printed circuits. . . . *Benrus Watch Co., Inc., New York City, has purchased the assets of Analab Instrument Corp., a subsidiary of the Jerrold Corp. The consolidation of Analab into Benrus's Technical Products Div. is aimed at expanding its growth in the electronic instruments field. Analab will continue to operate in Cedar Grove, N.J.* . . . Victory Electronics, Inc., Syosset, N.Y., manufacturers of electronics, communications and infrared devices has acquired Associated Electronic Corp., Richmond Hill, N.Y., and its subsidiaries. Associated will produce test equipment, ground support equipment, precision resistor networks and power supplies. . . . *Lundy Electronics & Systems, Inc., Glen Head, N.Y., has acquired from Bjorksten Research Laboratories, Madison, Wisc., all rights to the "Bjorksten Process" of metallizing glass fibers.* . . . Industrial Instruments, Inc., Cedar Grove, N.J., has acquired the assets of Precise Measurements Co. and Kalpa Scientific Laboratories, Inc., both of Flemington, N.J. PMC manufactures high-voltage and special purpose power supplies for industrial electronics, atomic physics, plasma research, capacitor charging and for experimental purposes. KI makes a special line of switches and connectors for use in high-voltage apparatus. Products of both acquisitions will be marketed under the Industrial Instruments name.

New Activities

Philco Corp. has established a corporate activity to be known as Philco Research Laboratories. The new activity brings under unified management the research activities of some 350 scientists, engineers and technicians at the firms' Newport Beach, Calif., and Blue Bell, Pa., facilities. Function of PRL will be "to translate Philco's dollar investment in the future into substantive advances in technology and new products and components. . . ." . . . *Reid Hill Electronics, Inc., has been formed in Amsterdam, N.Y., to design special precision components and to produce them as catalogue items in a minimum period of time.* . . . IIT Research Institute's management research div. has been made an independent for-profit consulting firm under the name, Corplan Associates. Corplan is headquartered in Chicago and The Hague, Netherlands, and is currently staffed with over 45 business specialists. Consulting areas to receive increased emphasis under the new organization include management development programs, personnel planning and consumer market research.

Industry Facilities

TRW Space Technology Laboratories has dedicated a $6.5-million rocket engine test site at San Juan Capistrano, Calif. The Capistrano Test Site is located on 1,250 acres of land, and will be used to test the 10,500-lb.-thrust engine STL is developing for the Lunar Excursion Module. Test stands will be able to accommodate engines with thrust up to 50,000 lbs., however. Future plans for the site include construction of facilities to house cryogenic, radioisotope and ordnance laboratories. . . . *Raytheon Co. is moving its Industrial Components Div. headquarters and production facilities from its Newton, Mass., plant to its Quincy, Mass., plant. The new plant was constructed specifically as an electronic components facility.* . . . Scientific Data Systems, Inc., has purchased a 142,000-sq.-ft. manufacturing facility in Los Angeles. Ground floor will house manufacturing and test facilities for all SDC computors, digital circuit modules and analog/digital systems components. Second floor of the two-floor building will be occupied by engineering and research and development personnel. . . . *Electra Manufacturing Co., Independence, Kans., has opened a new resistor production facility in Mineral Wells, Tex.* . . . Defense Electronics, Inc., Rockville, Md., has begun construction on the firm's new 85,000-sq.-ft. building located on a 16-acre site in Rockville. The $1-million plant is part of a long range planning program put into effect last year to facilitate delivery of the firm's present backlog and in anticipation of expected increased demands for telemetry and intercept receivers, data handling equipment, complete systems and related products for space and missile programs. . . . *Packard Bell Computer, a division of Packard Bell Electronics, has completed a move into new headquarters in Santa Ana, Calif. More than 400 engineering, marketing and administrative personnel are now situated in the new 75,000-sq.-ft., $1-million building.* . . . Long-Lok Corp., Los Angeles, has opened a new research and development laboratory "to speed up the development of new products and to improve present manufacturing processes." Long-Lok makes self-locking screws and bolts for the missile/space and other industries. . . . *Aluminum Company of America, Pittsburgh, has programmed major additions to both smelting and fabricating facilities at its Warrick, Ind., works.*

In The Courts

Bell Telephone Laboratories of New York has agreed to "dismiss with prejudice" its suit to overturn award by the U.S. Patent Office of the basic patent for solid-electrolyte tantalum capacitors to Sprague Electric Co. of North Adams, Mass. The Patent Office awarded patent for the device to Sprague based on an application filed by former Bell Telephone Laboratories of New York director of R&D Dr. Preston Robinson, now a member of Sprague's board of directors and a full-time consultant to Sprague. Bell Telephone contended that priority should have been given Bell employes rather than to Dr. Robinson.

contracts and procurements

AIR FORCE

$9,200,000—**The Boeing Co.**, Seattle, for continued work on *Minuteman* ICBM installation at Wing VI, Grand Forks AFB, N.D.

$7,800,000—**Rand Corp.**, Santa Monica, Calif., for research sevices related to missile/space projects.

$5,000,000—**Sylvania Electric Products, Inc.**, Waltham, Mass., for further work on a ground electronics system for the *Minuteman* ICBM.

$3,000,000—**The Boeing Co.**, Seattle, for continuation of work on the *Minuteman* launching system.

$2,900,000—**Thiokol Chemical Corp.**, Bristol, Pa., for further production of solid rocket motors for the *Minuteman* ICBM program.

$2,400,000—**Federal Electric Corp.**, Paramus, N.J., for work on the DEW line system in Canada.

$2,018,000—**Thiokol Chemical Corp.**, Alpha Div., Huntsville, Ala., for production of 42 solid rocket motors.

$1,300,000—**Avco Corp.**, Wilmington, Mass., for follow-on work related to re-entry vehicles.

$1,100,000—**North American Aviation Inc.**, Autonetics Div., Anaheim, Calif., for air-to-ground missile system instrumentation kits.

$798,500—**General Electric Co.**, Phoenix, Ariz., for EDP techniques supporting the Defense Intelligence Agency's production center.

$99,990—**American Science and Engineering, Inc.**, Cambridge, Mass., for research on optical radiation from air subjected to kilovolt electronic bombardment.

$92,986—**Stanford Research Institute**, Menlo Park, Calif., for a one-year study of energy conversion techniques.

$92,050—**Controls for Radiation, Inc.**, Cambridge, Mass., for investigation of high-energy radiation damage processes.

$75,714—**Bendix Corp.**, Baltimore, for equipment interface in the 412L air weapons control system.

$72,494—**Hayes International Corp.**, Birmingham, Ala., for supply of oxygen/hydrogen for Hill AFB, Utah.

$44,295—**Johns Hopkins University**, Baltimore, for development of equipment for the extreme ultraviolet and X-ray regions of the spectrum.

$40,559—**General Dynamics Corp.**, Astronautics Div., San Diego, Calif., for investigation of automatic methods of meteorological satellite data analysis.

$35,278—**Sperry Rand Corp.**, Blue Bell, Pa., for mathematical research on programming theory.

$32,856—**Massachusetts Institute of Technology**, Cambridge, Mass., for research directed toward development of an improved process for optical grating ruling.

$24,890—**ITT Data and Information Systems Div.**, Paramus, N.J., for a seven-month study of missile control display techniques.

United Technology Center, Sunnyvale, Calif., for a study of ignition of solid propellant rocket motors under vacuum (undisclosed amount).

ARMY

$1,777,354—**Philco Corp.**, *Aeronutronic Div.*, Newport Beach, Calif., for extension of advanced production engineering work on the *Shillelagh* guided missile system.

$739,976—**Sperry Rand Corp.**, Sperry Utah Co., Salt Lake City, Utah, for repair parts for the *Sergeant* missile system.

$714,400—**B. B. McCormick & Sons, Inc.**, Jacksonville, Fla., for construction of a perimeter dike, barge channel enlargement and navigation lock at Canaveral Harbor, Fla.

$530,000—**Thiokol Chemical Corp.**, Elkton, Md., for high-energy propellant evaluation.

$258,815—**Stanford Research Institute**, Menlo Park, Calif., for study of *Nike-Zeus* capabilities.

$222,488—**Northrop Corp.**, Nortronics Div., Anaheim, Calif., for engineering services related to the *Hawk* missile loader transport.

$200,000—**Raytheon Co.**, Andover, Mass., for one high-power illuminator radar for the *Hawk* missile system.

$135,500—**Mithras, Inc.**, Cambridge, Mass., for provision of two optical trackers for Project GLOW.

$56,241—**Perkin-Elmer Corp.**, Norwalk, Conn., for provision of a spectrophotometer.

$44,790—**American Bosch Arma Corp.**, Springfield, Mass., for fuel injector nozzles.

$35,521—**Victory Electronics, Inc.**, Syosset, N.Y., for provision of special battery chargers for use at the U.S. Army Electronic Materiel Agency, Philadelphia.

$25,810—**Motorola, Inc.**, Military Electronics Div., Scottsdale, Ariz., for provision of radar transponders.

NAVY

$4,200,000—**Hughes Aircraft Corp.**, Culvert City, Calif., for further work on the *Phoenix* missile system being developed for the TFX aircraft.

$2,600,000—**Planning Research Corp.**, Los Angeles, for two contracts to study data processing machines in classified research areas.

$1,900,000—**Westinghouse Electric Corp.**, Baltimore, for follow-on design and development of missile guidance components.

$1,100,000—**ITT Federal Systems Div.**, Nutley, N.J., for target detecting devices for use with the *Terrier* missile system.

$810,000—**Thiokol Chemical Corp.**, Denville, N.J., for hybrid propellants and propulsion research.

$650,000—**Northern Ordnance, Inc.**, Minneapolis, Minn., for long lead-time effort toward development of one guided missile launching system.

$74,699—**Thiokol Chemical Corp.**, Denville, N.J., for research and development on solid propellant exhaust gases.

NASA

$315,000—**Ion Physics Corp.**, Burlington, Mass., for a micrometeoroid impact simulator.

$200,928—**Hayes International Corp.**, Birmingham, Ala., for engineering services and related operations.

$73,000—**Avco Corp.**, Spaceflight Programs Office, Tulsa, Okla., for study of the effects of particle radiation on metal surfaces.

MISCELLANEOUS

$7,000,000—**Control Data Corp.**, Minneapolis, from the European Organization for Nuclear Research (CERN) for a 6600 computer system.

$4,000,000—**Control Data Corp.**, Minneapolis, from **North American Aviation, Inc.**, Space & Informtaion Systems Div., Downey, Calif., for the digital test command system for the *Apollo* acceptance checkout equipment.

$3,500,000—**Bell Aerosystems Co.**, Buffalo, N.Y., from **Grumman Aircraft Engineering Corp.**, Bethpage, N.Y., for positive expulsion propellant tanks for the reaction-control system of the *Apollo* Lunar Excursion Module.

$2,700,000—**ITT Communications Systems, Inc.**, Paramus, N.J., from the **Defense Communictaions Agency** for continued engineering services.

$1,851,233—**Metals and Controls, Inc.**, Attleboro, Mass., from **Union Carbide Corp.**, New York, for fuel assemblies for Oak Ridge National Laboratory's High Flux Isotope Reactor.

$1,000,000—**Clevite Corp.**, Aerospace Div., Cleveland, from **United Aircraft Corp.**, Pratt & Whitney Div. East Hartford, Conn., for *Apollo* fuel cell components.

$500,000—**Purolator Products, Inc.**, On Mark Couplings Div., Los Angeles, from **The Boeing Co.**, Aerospace Div., Huntsville, Ala., for development and production of couplings for the umbilical panel of the *Saturn S-IC*.

$318,000—**Computer Products, Inc.**, South Belmar, N.J., from **Hughes Aircraft Co.**, Culver City, Calif., for two Mark 111 analog computers for use in advanced missile and fire-control system applications.

$134,474—**F. B. MacLaren & Co., Inc.**, Huntington Station, N.Y., from **Grumman Aircraft Engineering Corp.**, Bethpage, N.Y., for two scanning optical heads for use in the *Apollo* Lunar Excursion Module simulator program.

Thiokol Chemical Corp., Wasatch Div., Brigham City, Utah, from **General Dynamics Corp.**, Electric Boat Div., Scoville, Ida., for inspection, ultrasonic cleaning, calibration and sealing of high-precision micrometers, thermometers and squares, and instruction on maintenance, care and handling of the measuring devices (undisclosed amount).

Goodyear Tire & Rubber Co., Aviation Products Div., Akron, Ohio, from **Aerojet-General Corp.**, El Monte, Calif., for production and installation of insulation liners for 3-million-lb.-thrust solid rocket motors (undisclosed amount).

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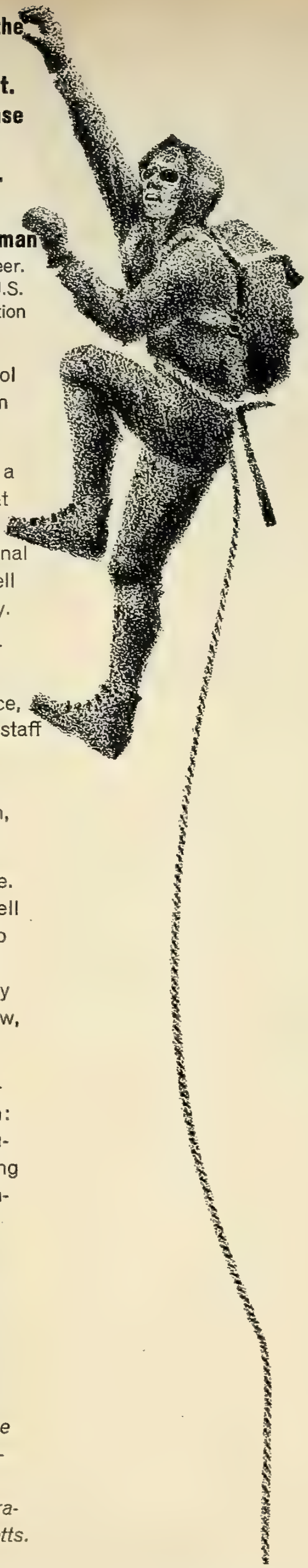
To me the response to challenge is the very core and mainspring of man's nature. A mountain is there; climb it. An ocean is there; cross it. A disease is there; cure it. A wrong is there; right it. The word is challenge . . . a challenge is there. Meet it.

James Ramsey Ullman
Author and Mountaineer.
Chronicler of recent U.S.
Mount Everest Expedition



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PERKIN-ELMER
TUBE CURRENT

New Product of the Week: Helium-Neon Laser

A continuous wave gas phase laser, the Model 5300, is being marketed by Optical Maser Dept., Perkin-Elmer Corp.

The instrument features hot-cathode dc discharge excitation and produces approximately 8 mw in the diffraction-limited mode and about 15 mw multimode. The unit is normally supplied with reflectors for visible red light output at a wavelength of 6,328 Å and is available with interchangeable reflectors for infrared output at 1.15 or 3.39 microns. The resonator consists of an 88-cm optical cavity. Primary power required is 117v ac nominal, 1.7 amps, 50 to 60 cps.

Circle No. 151 on Subscriber Service Card

DC Nanovoltmeter

A dc nanovoltmeter that features a sensitivity from 10 nv (10^{-8}v) fullscale to 100 mv in 18 overlapping ranges has been announced by Keithley Instruments, Inc.

The Model 148 measures and/or amplifies small dc voltages, and, by means of a zero-suppression feature, measures small changes in dc voltages. One-hundred times full scale may be suppressed. The instrument can be completely isolated from and ac power line and provides an accuracy of 2% of full scale on all ranges. It has a ±1v dc, 1 milliampere output to drive other instruments; accuracy at output is 1% full scale. The device can be operated by a nickel-cadmium 6-v battery pack with a maximum life of 16 hours from full charge.

Circle No. 152 on Subscriber Service Card

Data Acquisition System

Systron-Donner Corp. is marketing a multi-channel data acquisition system for thermocouple, strain and millivolt inputs.

The "Economy Systrac" 160-E1 features a 30-point relay scanner, a fully differential wideband preamp with programmable ranges and selectable filter, a solid-state high speed a/d converter and a 15/sec. line printer. System repeatability is ±0.06% at 10 mv full scale; common mode rejection is 140 db at 60 cps and 1,000 megohms input impedance. Expansion capabilities include adding inputs to total 300 and punched or magnetic tape outputs.

Circle No. 153 on Subscriber Service Card

DC/AC Calibrator

A portable dc/ac calibrator with an output from 0 to 111v ac or dc is being marketed by Ballantine Laboratories.

The Model 421 features ac that may be RMS or peak-to-peak at either 400 or 1,000 cps. Output voltage to four significant figures is indicated digitally. Accuracy is 0.15%.

Circle No. 154 on Subscriber Service Card

Cathode Ray Tube

Westinghouse Electric Corp.'s Electronic Tube Div. is marketing a high-resolution cathode ray tube designed to record electronic data on photographic film for data block or military data recording.

The WX-5063 has a magnetic deflection yoke and employs electrostatic focusing. Useful face diameter is 0.6 in.; spot size is 0.0008 in. The device has an anode voltage of 8 kv and meets temperature, vibration and shock requirements of MIL-T-5422E.

Circle No. 155 on Subscriber Service Card

Current Regulators

Semiconductor Magnetics, Inc., has developed a series of miniature, two-terminal, silicon current regulators, the CR5V series.

The units are adjustable from 1 to 50 ma, ±10%, with stability within 0.1% between 10 and 50v. The round case configuration measures 0.875 x 0.406 in; the rectangular configuration is 0.875 x 0.437 x 0.437 in. Weight is approximately 8 grams.

Electrical specifications (25 degrees) include: total current stability with voltage, 1.0%; threshold voltage, 9v maximum; interelectrode breakdown voltage, 50v minimum and maximum operating temperature, 175° C maximum.

Circle No. 156 on Subscriber Service Card

AC Millivoltmeter

The Model VM 77B millivoltmeter, offering 12 ranges between 0.001 and 300v ac fullscale, is available from Houston Instrument Corp.

The unit has a frequency range of 10 cps to 4.5 mc and can measure up to 100 mv on the most sensitive range. The meter scale is calibrated in RMS volts and in db with zero db related to 1 mw in 600 ohms.

HOUSTON INSTRUMENT CORP.

Input impedance is 10 megohms shunted by 20 pf. Calibration accuracy from 50 cps to 100 kc is ±3% FSD and is ±(3% + 3% FSD) from 15 cps to 2 mc.

Circle No. 157 on Subscriber Service Card

Photographic Rectifier

A flexible photographic rectification system, used to rectify high and low oblique aerial and panoramic photographs, has been introduced by Electronic Associates, Inc.

The Type 1.080 can work with photographs which have tilt angles up to 85 degrees, and in panoramic photographs that have sweeps up to ±60 degrees and tilts up to 25 degrees. The solid-state device has three distinct modes of operation—planar, strip and panoramic. It has four primary components, input coordinatograph, analog computer, X-Y plotter and a control system.

Circle No. 158 on Subscriber Service Card

Inert Gas Mixer

An inert gas mixer that weights 7 oz. and measures 5 x 1¼ in. is available from Modern Engineering Co.

The device operates by swirling two inert gases through two individual concentric cylinders that are milled in opposite directions. Two sheets of gas, less than 1/32 in. thick, cut into the paths of one another at the outlet to form an absolute mixture.

The unit may be attached to pressure compensated flowmeter regulators of any type. With 50-psi inlet pressure, positive accuracy is delivered regardless of differential in CFH.

Circle No. 159 on Subscriber Service Card

Q-Spoiler Device

Maser Optics, Inc., is marketing a Kerr cell laser Q-spoiling device which makes it possible for existing ruby lasers to deliver power pulses in excess of 200 million watts.

The Model 560 is designed around the electro-optical characteristics of nitrobenzene under an applied field, in conjunction with two Glanprisms. Pulse widths of 10 nanosecs and less have been achieved in laboratory and field tests, the company says.

Circle No. 160 on Subscriber Service Card

Cryogenic Accelerometer

Gulton Industries, Inc., is marketing a cryogenic charge accelerometer that measures shock and vibration in all cryogenic environments.

The device has a temperature sensitivity range of —425° to 200° F. ±10%. Transverse response is less than ±1.0% and charge sensitivity is 5 picocoulombs/g nominal. The unit weighs 1.2 oz. and measures 0.63 in. in diameter and 0.82 in. in height.

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A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; YUkon 6-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, California 90210—9301 Wilshire Blvd.; CRestview 4-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

Detroit, Michigan 48237—21990 Greenfield Road, Oak Park, Mich.; 547-8880
Michael Rouff

Chicago, Illinois 60601—1 East Wacker Dr., Room 1522; 321-1444
Charles E. Durham, Jr.

Miami, Florida 33022—P.O. Box 890, Hollywood, Fla.; WIlson 7-6072
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names in the news

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Ernest C. Collar, Jr.: Appointed corporate representative for Western Gear Corp.'s Washington, D.C. office.

Richard D. Ennen: Appointed general manager of Erie Bolt & Nut Co., Erie, Pa.

Joseph F. Clayton: Appointed director of program management of Bendix Corp.'s Systems Div., Ann Arbor, Mich.

John H. Coulombe: Named manufacturing manager for Leach Corp.'s Controls Div., Azusa, Calif.

Dr. Donald J. Farmer: Named president of General Technology Corp., Torrance, Calif.

Stanley R. Warren: Elected vice president-operations at McCormick Selph Associates, Hollister, Calif.

Dwin R. Craig: Joined Data Systems Engineering, Fairchild Statos Corp., Hagerstown, Md., as manager of research and engineering.

Philip C. Hintz: Appointed executive vice president of Standard Tube Co., Detroit.

Cornelius A. Melis: Named general manager of Duracarb, N.V., a subsidiary of the Adamas Carbide Corp., Weert, Holland.

Douglas A. Worth: Appointed manager of product marketing for the Electro-Optical Div. of Perkin-Elmer Corp., Norwalk, Conn.

John A. Pike: Promoted to project engineer in charge of the advanced design group for Beech Aircraft Corp.'s Boulder, Colo., division.

David C. Lawton: Named eastern sales manager for Fairchild Controls Div. of Fairchild Camera and Instrument Corp., Hicksville, N.Y. **Joseph W. Cooper** named production manager for the power tube department of Du Mont Laboratories Electronic Tube Div., Clifton, N.J.

Shepherd Sikes: Named national sales manager for aerospace products for U.S. Polymeric Chemicals, Inc., Santa Ana, Calif.

Eugene M. Pierce, Sr.: Appointed supervising architect of the Master Planning Program at Caltech's Jet Propulsion Laboratory, Pasadena, Calif.

J. H. Lewis: Named manager of *Centaur* procurement for General Dynamics Corp.'s Astronautics Div., San Diego, Calif. **F. L. Pike** named manager of project procurement.

Robert J. Whalen: Appointed group director of the space launching systems development directorate in the Manned Systems Div. of Aerospace Corp.'s El Segundo, Calif., Technical Operations.

Gary B. Eaton: Appointed staff services manager at ITT Federal Laboratories, San Fernando, Calif.

Dr. John C. Leak: Named manager of the organic chemistry department at Tracerlab division of Laboratory for Electronics, Inc., Waltham, Mass.

Howard Carlson: Elected vice president of Applied Technology, Inc., Palo Alto, Calif.

Dr. Theodore S. Benedict: Named assistant operations manager for materials by Motorola's Semiconductor Products Div., Phoenix, Ariz.

Dr. Howard J. Philipp: Appointed vice president-planning of Celanese Corp. of America. **Frank J. Pizzitola** appointed vice president-commercial.

Harry B. Gunther: Named director of production operations for Martin Co., Baltimore.

Dr. Steward S. Flaschen: Appointed director of component development for International Telephone & Telegraph Corp., New York City.

Gerald V. Sheffer: Appointed manager of the Chicago branch of Brush Instruments Div. of Clevite Corp.

Russ Perry: Appointed director of marketing of Hopkins Engineering Co., San Fernando, Calif.

Dominick J. Pastore: Appointed controller of Hill Electronics, Inc., Mechanicsburg, Pa.

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—when and where—

APRIL

The Combustion Institute, Western States Section, Spring Meeting, San Jose, Calif., April 27-28.

National Aeronautics Meeting and Production Forum, sponsored by SAE and ASME, Commodore Hotel, New York City, April 27-30.

IEEE and ISA Region 6 Annual Conference, Salt Lake City, Utah, April 29-May 1.

National Aeronautics and Space Administration's Annual Conference on the Peaceful Uses of Space, Boston, April 29-May 2.

Institute of Navigation, Space Navigation Meeting, Port-O-Call Inn, St. Petersburg, Fla., April 30-May 1.

MAY

American Society for Microbiology, Sheraton-Park and Shoreham Hotels, Washington, D.C., May 3-7.

10th National Aerospace Instrumentation Symposium, sponsored by ISA, Biltmore Hotel, New York City, May 4-6.

AIAA Aerospace Propulsion Meeting, Cleveland, May 4-6.

10th Annual Meeting of the American Astronautical Society, Hilton Hotel, New York City, May 4-7.

ASME Metals Engineering Conference, Sheraton-Cadillac Hotel, Detroit, May 4-8.

Second National Biomedical Sciences Instrumentation Symposium, Instrument Society of America, University of New Mexico, Albuquerque, May 4-7.

IEEE Fifth National Symposium on Human Factors in Electronics, San Diego, Calif., May 5-6.

Electronic Components Conference, sponsored by IEEE and EIA, Marriott Twin Bridges Motor Hotel, Washington, D.C., May 5-7.

Society for Experimental Stress Analysis Spring Meeting, Hotel Utah and Motor Lodge, Salt Lake City, Utah, May 6-8.

Acoustical Society of America Spring Meeting, Hotel New Yorker, New York City, May 6-9.

COSPAR Seventh Plenary Meeting, Florence, Italy, May 8-20.

International Conference of the Society of Aerospace Photography Engineers and Technicians, Palisades Park, N.J., May 10-15.

16th Annual National Aerospace Electronics Conference (NAECON), IEEE and Dayton Section of the AIAA, Biltmore Hotel, Dayton, Ohio, May 11-14.

Symposium on Applied Mathematics and Mechanics in Honor of Theodore von Karman, sponsored by AF Office of Scientific Research and the Society for Industrial and Applied Mathematics, Shoreham Hotel, Washington, D.C., May 11-14.

35th Annual Scientific Meeting, Aerospace Medical Association, Americana Hotel, Miami Beach, Fla., May 11-14.

ASME Design Engineering Conference, McCormick Place, Chicago, May 11-14.

M/R

special report

electro-optical systems

- state of the art
- direction of current research
- problems
- deficiencies
- requirements through 1975

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published june 1, 1964

advertising closes may 20

Why LASV Is Needed

DEBATE OVER THE PROPER MIX of missiles and manned aircraft in the U.S. strategic force has obscured a more fundamental problem. The question goes beyond the risk of increasing dependence on the missile force. Also to be considered is whether too much confidence is being placed in a single type of missile—the land-based, immobile, *Minuteman* solid-fueled intercontinental ballistic missile.

It is true that U.S. scientists and technicians have found the problem of anti-ICBM development a baffling one. Terminal defense with *Nike-X* appears to be a promising but highly expensive route, while Project Defender studies have all but ruled out any launch-phase or mid-course intercept. Nevertheless, to assume that the Russians have reached the same conclusion is dangerous.

It also is dangerous to assume that U.S. ballistic missiles are relatively invulnerable because they have been emplaced in silos. It is imperative that we have full and absolute assurance of the survivability of the U.S. strategic force in a situation where we concede the first strike.

There are no announced plans for any further buy of *Polaris* beyond the present 41-ship program, which would be one path to offsetting vulnerability of an immobile, land-based missile. Nor are there any announced plans to push the *Low-Altitude Supersonic Vehicle (LASV)* into the flight-test stage as possible insurance against Soviet AICBM development.

Plans for a manned long-endurance aircraft to be armed with standoff missiles still are in the early study stage—despite strong support from both Congress and the Air Force.

The *Mobile Medium-Range Ballistic Missile*, which would reduce vulnerability by truck-basing and sea-basing large numbers of smaller missiles, also appears consigned to oblivion.

The B-52 fleet is aging and there are no plans for a further B-58 buy.

Behind all of this is the fact of our present overwhelming strategic superiority over the Soviets. Behind it also is Secretary of Defense McNamara's conviction that we will be amply forewarned of any Soviet developments which might endanger that superiority.

We are not in agreement with this policy and we believe that such complete dependence on a single weapon is dangerous. We also believe that rapid development of the *LASV* is one extremely promising route to offsetting heavy dependence on *Minuteman.*

There is little argument in the Directorate of Defense Research and Engineering about the technical feasibility of the nuclear, global-range *LASV* ramjet missile. The development program so far has been a sound one. The Fiscal 1965 budget calls for a $20-million expenditure to continue this development, but does not provide for a flight-test program.

Tests of the flightweight Tory II-C reactor are due in a few weeks. Atomic Energy Commission officials expect these tests to prove out the technology.

The next logical step, and one which should be taken without delay, is a flight-test program. Plans for such a program have the backing of both Ling-Temco-Vought, the prime *LASV* contractor, and the Air Force.

If full-power tests of Tory II-C during the spring and summer go as expected, the program should be moved as rapidly as possible into a flight-test program. This is seen now as a limited test program of the *X-15* type, employing some five or six test vehicles. It would cost approximately $200 million.

Dept. of Defense philosophy in awaiting results of the Tory II-C tests in Nevada before pressing ahead with an *LASV* flight test program is sound. But once the tests are successful, no time should be lost in initiation of the flight test phase.

We believe *LASV* should be brought into the inventory as quickly as its technology permits. It offers the capability of striking the Soviet Union from any direction, it offers a low-altitude non-ballistic approach as a safeguard against Russian development of an AICBM, it offers mobility, it offers recallability not possessed by ballistic missiles, and it offers a patrol capability.

Speaking of *LASV*, an AEC official said recently that a full weapons systems approach could not be justified because Secretary McNamara has said we presently have all the systems we need. We do not agree with that. *LASV* offers such an entirely different capability that we believe it is needed in the inventory for just that reason.

Without question, this may be uneconomic. But should the dependability of U.S. ICBM's be in question—to use Secretary McNamara's own definition—then *LASV* would appear to be one of the best investments ever made by this nation. Undoubtedly, it costs money to provide for such a contingency but this nation certainly can afford it.

RESPECTED REP. CARL VINSON (D-Ga.), chairman of the House Armed Services Committee, put the reason for defense investments in clear terms during the debate earlier this year on the DOD Authorization Bill. He said:

"We are living in an age of much more than technological advance—it is more an age of technological explosion. This being so, we have no choice but to progress as the state of the various arts permit us to progress and, in the area of defense, we are not seeking things that are better merely because they are better—but because our national survival will depend upon them being better.

"A better strain of corn, a better breed of cattle is a good thing to have. But we could live without them. . . .

"In the area of defense, however, second best is simply not good enough. We must make every effort to keep well ahead of the enemy in our aircraft and missiles and naval vessels. We are not talking about luxury here. We are talking about sheer, stark necessity."

Although Rep. Vinson was not talking specifically of *LASV*, the venerable military statesman could not have put the case for it in any better terms.

William J. Coughlin

CAREER NEWS FROM HUGHES

Aerospace Divisions in Culver City, California

NEW AND CONTINUING PROGRAMS AND PROJECTS

F-111B PHOENIX Missile System
SURVEYOR Lunar Landing Vehicle
SYNCOM Synchronous Communications Satellite
POLARIS Guidance
TOW Anti-tank Missile
VATE Automatic Checkout System
FALCON Missiles
ARPAT
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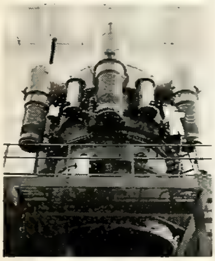

This giant environmental test chamber at Hughes new Space Simulation Laboratory is just one of a complete range of facilities maintained by the company for the Technical Staff. Hughes physical plant and professional atmosphere, unexcelled in industry, encourage individual achievement.

GROWTH OF THE ENGINEERING STAFF

Of the over 9,000 employees of these divisions, 3,000 are Members of the Technical Staff. Average length of experience is 11.0 years. Average age is 33 years.

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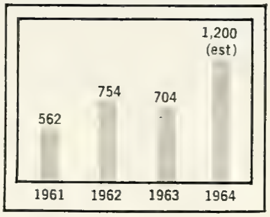
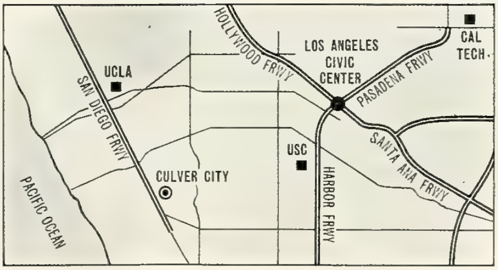


HUGHES/CULVER CITY & LOS ANGELES



Hughes Aerospace Divisions at Culver City offer engineers and scientists a unique combination of urban and suburban advantages. The plant is immediately adjacent to a major freeway. Los Angeles Civic Center is about a half-hour distant. Beach communities are just minutes away. Attractive residential neighborhoods are nearby. UCLA, USC and Cal Tech offer outstanding educational facilities.

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The capability to produce precision castings is only one specialized segment of Electronic Specialty's corporate activities. Extensive programs are also underway in the areas shown at right. For further information write to William Marcy, Director of Marketing.

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SYSTEMS:

Systems Laboratories conduct research, development and study programs in reconnaissance, electronic countermeasures, interferometer phased array systems, and total energy packages; integrating divisional components, sub-systems, and specialized engineering and scientific skills.

For information concerning the corporate systems capability, product line, or research and development programs, write to the Director of Marketing, address below.

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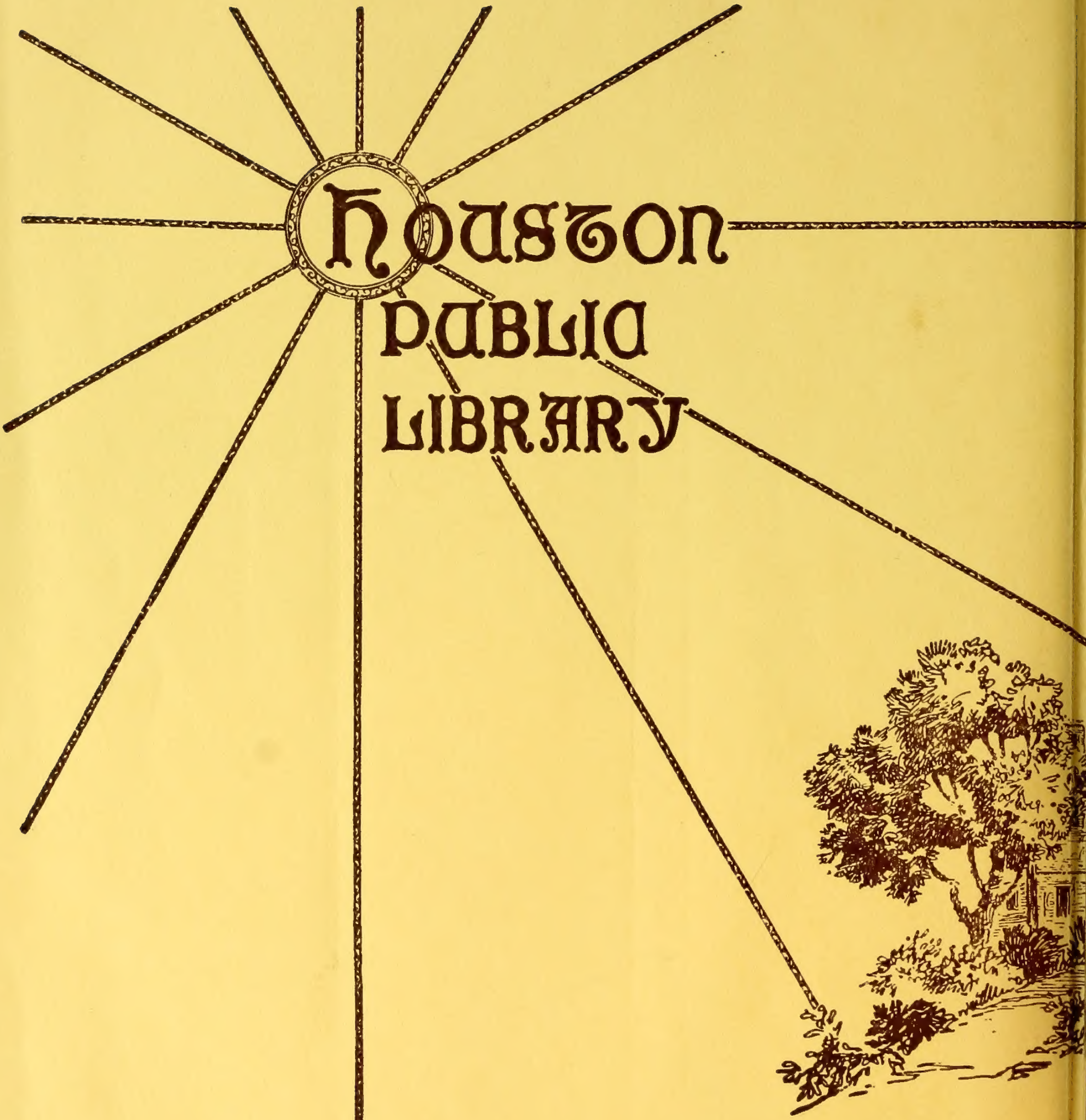
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